SCIENTIFIC AMERICAN SUPPLEMENT

VOLUME LXXVI
NUMBER 1973

NEW YORK, OCTOBER 25, 1913

10 CENTS A COPY
$5.00 A YEAR

Front end of machine on which Prevost won the Gordon Bennett Cup.

THE RHEIMS AVIATION MEETING.—[See page 260.]

The British Association for the Advancement of Science

Abstracts of the Principal Papers

The Nature of the Electro-magnetic Waves Employed in Radio-telegraphy and the Mode of Their Propagation.

By Professor G. W. O. Howe, M.Sc.

A very clear conception of the nature of the electro-magnetic waves employed in radio-telegraphy can be obtained by considering those electro-magnetic waves which exist in the space between the two conductors of a single-phase transmission-line. If the conductors are flat, parallel strips, close together, and connected at the sending end to the terminals of an alternator, there is a certain value of the non-inductive load at the receiving end which will absorb the arriving energy without any reflection. Under these conditions the current and voltage are in phase all along the line, and the same is true if the line is assumed to be of infinite length. Line-resistance and leakage are assumed to be negligible. It follows from this that the electric and magnetic fields at any point have their maximum values at the same moment. Instead of two parallel strips transmitting energy in one direction, two parallel discs of infinite extent can be imagined with the alternating P.D. applied between their centers. Energy would then be transmitted radially in all directions in the plane between the discs. The earth could take the place of the lower disc, while the upper one could be represented by a conducting horizontal plane some distance above the earth. The waves produced would be truly cylindrical, whereas those employed in radio-telegraphy are spherical. If, now, the upper disc is replaced by an inverted conducting-cone of infinite extent, with its apex almost in contact with the earth, the alternating P.D. being applied between the apex and the earth, the electro-magnetic waves will be almost identical with those employed in radio-telegraphy, and will vary in the same way with the distance from the sending station. This imaginary multi-directional transmission-line, consisting of a lower plane (the earth) and an inverted cone, lends itself to simple calculation, because, like an ordinary transmission-line, and unlike the two parallel discs, it has a constant inductance and capacity per mile. It can be shown that if the angle between the cone and the earth is 70 deg., the relations between the magnetic and electric fields near the earth's surface and the total energy radiated are identical with those existing in the ordinary radio-telegraphic wave. As in the transmission-line already considered, the current and P.D. will be in phase at every point, and therefore, contrary to the usually accepted view, the horizontal magnetic field and the vertical electric field due to a sending antenna are not 90 deg. out of phase, but are approximately in phase, except in the immediate neighborhood of the antenna. This also follows from the fundamental equations of a progressive, as distinct from a stationary, electro-magnetic wave.

Contacts Between Electrical Conductors.

By W. H. Eccles, D.Sc.

When a current is passed across a "loose contact," the relation between the applied electromotive force and the current produced is, in general, not a linear one, and no sufficient explanation of the observed phenomena has hitherto been offered. The present author investigates whether the behavior of contacts can be accounted for by purely thermal actions in the matter near the contact. The Joule, the Peltier, and the Thomson effects will all play a part, and the alterations of resistivity with temperature, as well as alterations of the geometrical configuration of the surfaces in contact caused by thermal expansion, ought all to be taken into account. These thermal effects are, of course, most noticeable in contacts between bad conductors of electricity and of heat, as, e.g., the natural crystalline oxides and sulphides. It is advantageous to separate contacts into two classes: First, those between like substances; second, those between unlike substances. In the first class there is in general no thermoelectric action, and the non-linearity of the relation between applied E.M.F. and current is mainly due to resistivity changes produced by Joulean heating. In the second class there is in general some thermoelectric action imposed on the resistivity-temperature phenomenon; and in the case of the crystalline substances mentioned the thermoelectric actions may be the more important. For the first class, theory yields a cubic equation connecting E.M.F. and current. Experiments are adduced by the author which show that the thermal explanation is in many cases sufficient. In the second class, thermoelectric theory yields a quantic equation. The curve connecting E.M.F. and current takes very various shapes, according to the signs and the relative magnitudes of the Peltier and Thomson coefficients in the substances forming the contact. The author has measured these coefficients in some typical substances, and has thus carried out a comparison between the theoretical curves and the experimental curves of contacts between pairs of these substances. The evidence gathered in this way tends in the main to support the theory.

Possible Methods of Measuring the Amount of Atmospheric Pollution by Suspended Matter, such as Smoke, Dust, etc.

By J. S. Owens, M.D.

The following methods were considered:

1. Filtering a measured volume of air through a cotton or asbestos wool filter, and weighing the filter before and after. This method was used by Mr. Russell for the Meteorological Office some years ago, and appeared to give good results. It requires considerable technical skill, and has inherent difficulties, such as moisture in the wool; it is doubtful if it would give sound results except perhaps in very impure air, as during a smoke fog. It also requires elaborate apparatus. The method is described by G. W. J. Russell in "The Monthly Weather Report," 1884 and 1885, by Cohen in "J.S.C.I.," 1887, and by F. Clowes in "J.S.C.I.," 1903.

2. All rain or other deposit falling on a gage of known area may be collected, evaporated, and the residue weighed and analyzed. This method was used in the investigations made by *The Lancet* about two years ago to get the sootfall of London. It does not, strictly speaking, give the amount of air impurity, but the amount which falls on a given area (a) in rain, snow, etc.; (b) during dry weather; (a) and (b) are not separated but estimated together. The apparatus used may be very simple, and it is now adopted by the Committee for the Investigation of Atmospheric Pollution.

3. Aitken's Dust Counter. This is an instrument devised by Mr. John Aitken for counting the number of dust particles in air. It is described in "Trans. R.S. E.," Vols. XXX. to XXXVI. No attempt is made to obtain the composition of the dust particles.

4. Glass plates may be exposed to the air for a certain time, then washed in water, and their opacity measured. This method was devised by Professor Cohen, and used in Leeds. It appears to be useful only for catching matter which will stick to a glass plate—e.g., tarry soot. It would seem also that the indication given must be affected by the amount of tar present in the smoke of a city—i.e., if there is not sufficient tar present to make the deposit stick, the indication will be too low. It aims only at comparative results.

5. A jet of air may be caused to strike a glass plate coated by some sticky substance, and the opacity measured. This method may be used either: (a) By causing the air-jet to play on the glass for a fixed time, and then measuring the increased opacity by comparison with a calibrated scale; or (b) the jet may be made to play for such time as will cause a definite opacity, and the time required compared with a calibrated time-scale. This method is suggested for discussion, and has not been used.

6. A measured volume of air may be drawn through filter-paper, and the degree of discoloration produced on the paper measured or compared with calibrated papers. This method has been tried in Glasgow with considerable success; but it would seem to give results which depend somewhat on the color of the matter caught as well as its amount.

7. An optical method might be used by which the opacity, to a standard light, of a column of air of given length is measured. This could probably be arranged to give the quantitative amount of impurity present by preparing a scale of opacity from measurements taken on air with known amounts of suspended matter present.

8. Rain might be caught, and its opacity compared with a standard scale made by adding definite quantities of soot to distilled water. This method, or a somewhat similar one, was used by Dr. Fritzsch for measuring smoke in chimneys. (See Donkin in *Engineer* May 26th, 1899.) The method is open to the same objection as No. 2, also its results would depend on the nature of the impurity as well as the quantity present.

9. Boxes may be exposed having a collecting surface of one square foot and the contents collected and analyzed. Such boxes were devised by Mr. Peter Fyfe, Chief Sanitary Officer, Glasgow, and exposed in that city at prominent positions. The method is a simplified form of No. 2.

Effect of Atmospheric Conditions on the Strength of Signals Received at Liverpool from Paris and some other places together with an Account of the Diurnal Variations in the Energy Received.

By Professor E. W. Marchant, D.Sc.

Measurements have been made over a considerable period of time, but those described herein deal mainly with observations during the month of July. The most accurate observations have been obtained with signals sent out by the observatory at the Eiffel Tower at 10.45 A.M. and 11.45 P.M. The method adopted in the earlier tests was to use a "Perikon" detector in series with galvanometer and telephones, the measurement of strength being made by the cumulative deflection due to a series of known signals. This method was not found satisfactory with the Paris signals, for which the antenna current used was known, and in the later tests an Einthoven string galvanometer has been employed by which the strength of signal for each individual spark at Paris could be observed to within ± per cent. The results obtained show that there is a maximum variation from 0.6 to 1.3 in the strength of the signals received on different days in the same month; the average strength of signal being assumed to be 1.1, and that the current received on a fine, clear night is about 1.7 times as strong as that received in the day-time. Although no certain relationship can yet be regarded as established between the strength of a signal and the weather conditions at the sending and receiving stations, so far observation has shown that rain in Paris always corresponds with a diminution in strength of received signal. In one case, with a wind of 6 meters per second velocity, blowing in a northwest direction, the signal strength fell to half its normal value. The most favorable condition for signaling appears to be a cloudy sky at both sending and receiving stations, the signals being weaker when the sky is clear, or covered with light clouds. Rain at the receiving station appears to have a comparatively small influence on the strength of the received signals. The result of a set of special signals sent from the Eiffel Tower on the evening of Saturday, July 26th, 1913 (by the courteous arrangement of Comm. Ferrie), at intervals of 30 minutes, between 7 and 10 P.M. (which includes the time of sunset), shows that the increase in strength of night signals occurs just after sunset, there being a sudden increase in strength of about 70 per cent. This change is quite sudden, there being comparatively little alteration in signal strength until the sun has set, and no perceptible increase in strength afterward. There appears to be some evidence that signals are slightly stronger just after sunset than during normal night conditions.

Short Heat Tests of Electrical Machines.

By W. R. Cooper, M.A., B.Sc.

Tests of dynamo-electric machinery are generally carried out extending over six hours, in order to determine the maximum temperature rise. Suggestions have been made that such tests might be considerably shortened by assuming that the curve of temperature rise is a logarithmic curve. The author gives a brief account of the methods that have been proposed and points out that the "thermal time constant," on which the behavior of a body in heating and cooling largely depends, should be found most easily, and under less complex conditions, from the cooling curve. In order to test the applicability of the various methods, tests were made upon a 5 k.w. motor-driven dynamo. The curves of temperature rise were found to be fairly logarithmic. The usual method of running a machine on tests is to run on constant output with constant voltage, which necessitates increasing the input to the field coils as their resistance rises. A truly logarithmic curve can only be expected if the input of heat is at a constant rate, so that a better result would be expected if a machine were tested with constant input to the field coils, the output of the machine being constant, but at varying voltage. Actually this method of testing was not found to give an improved result. Graphical methods appear to give better results than formulae, as the latter are very sensitive to small errors in the data. In any case only certain portions of the temperature-rise curve should be used, and any formulae depending on the initial rate of temperature rise should be avoided, as this is difficult of exact determination. The curve of cooling has certain advantages; only a small portion of it seems suitable for graphically determining the thermal time constant, but this quantity can be derived much more readily by the time taken for a certain percentage drop of temperature rise. In the results given there is better agreement between the values found for the thermal time constant than for the maximum temperature rise. It is suggested that a fair approximation to the maximum temperature rise can often be obtained by testing for a time equal to, say, 1¼ times the thermal time constant, deducing the value of this constant from the cooling curve, and thence the maximum temperature rise from the heating curve.

A New Method of Starting Mercury-vapor Apparatus.
By John S. Anderson.

In the best types of mercury-vapor lamps and rectifiers at present on the market, the arc is started by tilting the lamp or rectifier, either by hand or automatically. Now, this tilting arrangement is very often inconvenient. This is found to be especially the case when one is dealing with lamps used for scientific purposes. For example, in carrying out experiments on the Zeeman effect, a mercury-vapor arc lamp is extremely suitable. But the difficulty arises from the fact that the lamp must be placed between the poles of an electromagnet, the distance between the poles being usually so small that any tilting apparatus that may be employed interferes with the proper mounting of the lamp. Mr. G. B. Burnside and the author have overcome this difficulty by constructing a lamp which may be fixed in position between the poles of an electro-magnet, or in any other suitable position, and then started without having to be tilted. This is brought about by the employment of a heating arrangement near one of the electrodes—preferably the negative electrode. The lamp-tube is provided with a small vessel near this electrode, the vessel having a re-entrant portion, or recess, in which a heating element is placed. The part of the tube immediately above this small vessel and its recess is constricted. The heating element may conveniently consist of a small coil of platinum wire wound round a suitable support; it may be placed in the recess of the small vessel, or removed at will, without interfering with the vacuum of the lamp. The heating coil of wire is connected in series or in shunt, in the latter case being provided with an automatic cut-out. An external resistance is placed in series with the lamp. Before starting, the small vessel is full of mercury, which forms a continuous connection inside the tube, between the positive and negative electrodes. When the electrical current is switched on, the heating coil becomes incandescent, and the heat given off by the wire goes to raising the temperature of the vessel and its contained mercury, there being no appreciable loss by radiation into the surrounding air. Very little heat is required, because the first bubble of mercury-vapor formed rises to the constricted portion of the lamp, and is there caught, thus breaking the continuity of the mercury inside the lamp and starting the arc. Owing to the resistance of the mercury-vapor which is formed once the arc is started, the current is cut down to the value required for running the lamp. The platinum wire of the heating element can be made of such a thickness, and the external resistance can be so adjusted, that the wire does not emit heat when the lamp is working, but becomes incandescent when the lamp is started, the action being quite automatic.

Radiation.
By J. H. Jeans, F.R.S.

Any discussion of the nature of radiation is inextricably involved in the larger question as to the ultimate form of the laws which govern the smallest processes of nature. The laws which have so far been believed to be the ultimate laws of nature have been expressible in the form of differential equations, implying continuity and infinite divisibility of time and space. It now appears that these laws must be revised. The problem is seen at its simplest in the case of black-body radiation. The number of independent vibrations within a given range of wave-length, say $d\lambda$, in any continuous medium can easily be counted up; it is found to be $4\pi\lambda^{-4}d\lambda$ per unit volume for sound-waves in a gas $8\pi\lambda^{-4}d\lambda$ for light-waves in ether, and $12\pi\lambda^{-4}d\gamma$ for elastic waves in a solid. Hence, if we know the partition of energy according to wave-length in any medium, we can deduce the energy of each vibration.

For instance, in a gas, the molecules move with velocities determined by the well-known law of Maxwell. The motion of the molecules can be resolved, by ordinary Fourier analysis, into that of regular trains of waves, and the partition of the total energy per unit volume is in this way found to be $4\pi RT\lambda^{-4}d\lambda$ where T is the temperature (abs.) It follows that each wave has an average energy R.T. This could have been predicted: the theorem of equipartition of energy shows that the average energy of each wave must be R.T. in any medium governed by ordinary mechanical laws. On the other hand, the partition of energy of light waves in either is found experimentally to be

$$8\pi RT\lambda^{-4}d\lambda \times \frac{x}{e^x-1}, \text{ where } x = \frac{h\nu}{RT}$$

showing that the average energy of a vibration of wave length λ is

$$RT \times \frac{x}{e^x-1}$$

In a solid, the random heat-motions of the atoms must also be capable of resolution into trains of waves; but no experimental method is available for determining the partition of energy between these waves. But the very valuable work of Debye on specific heats of solids has given an indirect, although very convincing, proof that the average energy of a heat-wave in a solid must be exactly the same as that of a light-wave in ether—namely

$$RT \times \frac{x}{e^x-1}$$

Knowing the mean energy of each vibration when in a state of thermo-dynamical equilibrium, it ought to be possible to work back to some knowledge of the type of laws of motion producing this partition of energy. For the special case in which the mean energy is

$$RT \times \frac{x}{e^x-1}$$

the problem has been solved by Poincaré. The quite definite result obtained is that the exchange of energy between matter and ether must take place by finite jumps of amount ε, given by $\varepsilon = h\nu$; thus the result of experiment leads inevitably to the law

$$RT \times \frac{x}{e^x-1}$$

and this in turn leads inevitably to the quantum-hypothesis in its entirety; as Poincaré's work almost compels us to do, we inquire what other phenomena bear witness to its truth. Primarily, there is the photo-electric effect: the energy imparted to an electron appears to be exactly ε, where $\varepsilon = h\nu$. Here ε is determined by ν: but in some phenomena ν may be determined by ε. The energy may arrange itself as required (for example) by the law of conservation of energy, and the frequency of radiation may be determined by the amount of ε then available. Thus the wave-length of Röntgen rays may be determined by the energy of impact; a dissipation of energy may result in a lowering of frequency of light (fluorescence), cooling may cause radiation to run toward the infra-red (black-body radiation). By following this principle implicitly, Dr. Bohr has arrived at a brilliant and very convincing explanation of the laws of spectral series. But against the quantum theory seem at first sight to be arranged almost all the well-established results of the undulatory theory of light. The great difficulty is to reconcile the two sets of facts. A question to be considered is whether it may not be necessary to discard Maxwell's teaching that light and electro-magnetic waves are identical. Consider a few electrons shut up in a radiation-free and perfectly reflecting enclosure, left to move freely. According to ordinary laws, the electrons must set up an electro-magnetic field, and the energy of this field must ultimately conform to the law of equipartition $8\pi RT\lambda^{-4}d\lambda$. Would this really happen? If not, where is the point of departure from the ordinary law? If it does happen, is the resulting energy identical with light, or something quite different? There is a large mass of evidence that everything, from long Hertzian waves to the shortest Röntgen rays, obeys the laws of reflection and refraction required by the undulatory theory. The boldest and simplest attempt at reconciliation between the conflicting theories lies in abandoning the ether altogether, and relying on some purely descriptive principle, such as that of relativity. There is probably no reason why the ultimate interpretation of the universe should be expected to be dynamical rather than kinetic and descriptive. Any attempt at a dynamical interpretation demands a consideration of the meaning of h. The following suggestion is put forward very tentatively. The value of h is given by

$$\frac{h}{2\pi} = c\frac{(4\pi e)^2}{V}$$

where c is a numerical constant, of which the value appears, from the best experimental determinations, to be exactly unity. Is, then, the new unit h anything more than a reappearance of the old unit $4\pi e$? Is the atomicity of action or energy or angular momentum anything more than the atomicity of electricity? The constancy of e throughout the universe is most naturally explained by supposing that the electrons are formed out of some primordial substance (e.g., ether), and that the constancy of e is implied in the properties of this substance. More definitely, we can imagine the equations of the ether to involve e or (h) as well as the Maxwell terms: these equations will form the basis of the new dynamics. If, in forming the equation of wave-propagation in the ordinary way, the new terms happen to be eliminated out, then the equation of propagation

$\nabla^2\phi = a^2\dfrac{d^2\phi}{dt^2}$ will be true in the new dynamics as in the old, and there will be no discordance between the quantum theory and the undulatory theory. But the new terms will stay in when the equations are applied to problems of interaction between matter and ether, so that h may be expected to play a part in all such phenomena.

A Development of the Theory of Errors with Reference to Economy of Time.
By Mayo Dyer Hersey.

An enumeration of the results to which we are led in studying the problems of "design" and of "computation" is followed by a detailed consideration of the problems of "observation." In connection with the problem of designing (or adjusting) apparatus so as to secure the most favorable result in a limited time, a criterion for "best magnitudes," previously proposed (Jour. Wash. Acad. Sci., Vol. I., 1911, p. 187), is here further considered, and illustrated by an application to the interferometer. In regard to computation, the availability of an automatic device for linear least-square adjustment (Jour. Wash. Acad. Sci., Vol. III., 1913, p. 296) makes it now desirable to have some means of throwing an assumed relation into linear form without disturbing the relative weights of the observations. A general formula for doing this is here proposed and applied to the determination of thermal expansion co-efficients. Finally, the investigation of economy of time in taking the observations themselves leads to two distinct problems; first, that of the division of time among the components of an indirect measurement; second, that of the best grouping of observation in determining any one quantity. The solution of the first problem comes out in terms of three data—namely, the relative precision of, and the relative time consumed in, a single observation on the respective components; together with the derivatives expressing the sensitiveness of the result with respect to the several components. Of these data the first two are postulated, while the third is implicitly contained in the equation which defines the measurement in question. The solution is independent of the existence of constant errors. The second problem consists in establishing the most profitable compromise between the extremes of (1) repeating a large number of readings under the same conditions (or on the same sample), in order to diminish the effect of observational errors; or (2) resting content with a lower precision on each determination, in order to cut down systematic errors by making numerous independent determinations (or by trying many different samples). The most economical number of observations to make in any one group before stopping to change conditions (or to set up a new sample) in preparation for a new group, is directly expressible in terms of two postulated data. There are, first, the ratio of the average observational error to the average systematic error anticipated; and, second, the ratio of the time required in preparing for a new group to the time used in a single observation. This result is independent of the total time available. The first problem is illustrated by the division of time in a gravity determination of Kater's pendulum; the second, by the determination of the heat of combustion of coal from a series of samples. A combination of the two problems may also arise. The solution is equally straight-forward. Throughout, the object of the paper has been to establish certain general principles governing the accuracy attainable in physical measurements, independently of the particular apparatus or process in question.

On the Transmission of X-rays Through Metal.
By H. B. Keene, Assistant Lecturer in Physics, University of Birmingham.

A photographic examination of secondary Röntgen radiation leads to results of a different nature from those obtained by the ionization method. When a narrow cylindrical pencil of X-rays is made to pass normally through thin-rolled metal sheets, and fall upon a photographic-plate placed behind and parallel to the sheet, some curious patterns are obtained. These patterns fall into two classes: (a) in which the central spot produced by the direct beam is surrounded by an irregular halo of smaller spots, and (b) in which the central spot is surrounded by faint extended patches, forming a perfectly symmetrical pattern. The design varies with the metal. Class (a) markings are given by metal sheets which have been annealed, while the symmetrical patterns of class (b) are only obtained with newly-rolled sheets which have not been annealed. It appears that the spots of the former are due to reflections from the microcrystals within the metal, while the symmetrical patterns of the latter are produced by the structure imparted to the metal in passing through the rolls. These star-like patterns are evidently analogous to those obtained when a beam of light passes through a crystal which appears streaky to the naked eye, the striations acting as a diffraction grating. (H. S. Allen, *Nature*, 91, p. 268.)

The Nature of Life.

Professor J. Reinke, of the University of Kiel, dealt with the nature of life in a paper which he read in German. The more, after the united endeavors of zoologists and botanists, the essential concordance of animal and vegetable life had come to light, he said, the more the fundamental problem of science had come to the fore. What was the nature of life, and how was it to be explained? Often people had tried to solve this problem more in accordance with preconceived opinions than with the methods of exact science, that simply asked and inquired, unconcerned for the answer. For his part, he refused both the exclusive vital and the exclusive mechanical dogma; but he did not wish to subordinate the living to the lifeless matter, and to

draw from the dominion of lifeless nature only parallels for the explanation of life.

He was sure that the laws of energy were valid in the organism as well as in unorganized nature, and that the change of matter and of power in animals and plants depended on them. Life was based upon such transformations of energy, and these elementary processes were bound to elementary mechanisms in the cells of animals and plants. These elementary processes and elementary mechanisms were not thrown together without order in the living body; they were united by an invisible string or chain, and this invisible chain or force that maintained the order among the elementary processes represented the true difference between life and any event in lifeless nature. He called it the "Lebensprinzip."

The single elementary processes were accessible to physiological analysis; not so the "Lebensprinzip." Therefore, the elementary processes formed only one part of the living creature; the "Lebensprinzip" formed the other part. By the latter the former were united to a living unity, an individual, and it could continue the individual in its offspring. In the ontogeny, each stage of development from the egg-cell to the adult state was united by the "Lebensprinzip." Each elementary process in animals and plants could be imagined byitself; not so the "Lebensprinzip." It showed only the relations among the elementary processes or mechanisms; therefore it was a law that, like all laws, was invisible and impalpable. The "Lebensprinzip" was the ordered connection of the elementary mechanisms within the living body; its ordered efficacy excluded an accidental aggregation of the elementary mechanisms in the body of plants and animals. Therefore, life had its own laws, as well as light, heat, chemistry, which did not exclude the fact that the physico-chemical laws reigned in the elementary processes of a living body. Thus any mystical interpretation of the "Lebensprinzip" was excluded, as it was applicable to the old "vis vitalis" or "vital force." The "Lebensprinzip" was not a force or a power; it was a principle of succession, of order, of regulation, and of harmony.

The Rheims Aviation Meeting and the Gordon Bennett Cup Race

The Winners and Their Machines

By John Jay Ide

The aviation meeting at Rheims, organized by the Aero Club de France, was held over the Aerodrome de la Champagne, Saturday, Sunday, and Monday, the 27th, 28th, and 29th of September. It will be remembered that there was much feeling on the part of many members of the club on its determination to use this aerodrome, which the bankrupt Deperdussin had put at its disposal before his arrest. Louis Blériot and the Farman brothers refused to have anything to do with the meet under the circumstances.

The following seven makes actually took part in the competitions: Bréguet, Caudron and Goupey (biplanes); and Deperdussin, Morane-Saulnier, Nieuport, and Ponnier (monoplanes). They are sufficiently representative to give an idea of the actual state of perfection which the French aviation industry has attained. To one accustomed to the meetings of two or three years ago it was a revelation to see the precision with which the flying was carried on. Successfully to accomplish the start of such an event as the cross-country race, in which seven biplanes and then seven monoplanes took flight at the same moment, would have been impossible two years ago, and extremely difficult last year. This, of course, is largely due to the improvement in the Gnôme motor, which was used by eleven of the fourteen starters in the race.

Twenty-five machines took part in the events disputed on the course laid out on the aerodrome in the shape of a symmetrical hexagon with four short sides and two long ones. The perimeter was 10 kilometers (6.21 miles).

SATURDAY, SEPTEMBER 27TH.

The most important event of the first day was the French eliminatories for the Coupe Internationale d'Aviation, otherwise known as the Gordon Bennett Cup. The elimination race was for a distance of 100 kilometers (62.1 miles). Prévost, the winner, in his 160 horse-power Deperdussin, created new world's records for all distances up to and including the 100 kilometers, which he covered in 31 minutes 22 2/5 seconds. His highest speed was 192 kilometers (119 miles) per hour, which gave rise to the hope that 200 kilometers (124 miles) per hour might be reached in the Gordon Bennett. The other two pilots to qualify were E. Vedrines (the brother of Jules) and Gilbert. Rost was fourth to finish and so became an alternate.

In the afternoon the Slow Flying Contest was held, the competitors in which had to qualify by first making a circuit at 90 kilometers (55.8 miles) per hour or better. Those who succeeded in doing this were then required to fly as slowly as possible two kilometers (1.24 mile) in a straight line in both directions. In order to easily detect any varying from the straight line a maximum height of 50 meters (164 feet) was prescribed. The winner of this interesting event was Derome on a Bréguet.

The final event was the Height Competition, with and without passengers. The world's records were not beaten, although Gilbert, in the class for pilot and one passenger, came within 562 meters (1,843 feet) of Perreyon's mark of 4,960 meters (16,668 feet). He would have had to exceed it by 150 meters (492 feet), however, to have it count.

M. Deutsch de la Meuthe (on right), president of the Aero Club de France, talking to Garros, hero of the trans-Mediterranean flight.

Below are listed the tables of the first day's performances:

French Eliminatories for the Gordon Bennett Cup.
100 kilometers (62.1 miles).

1. Prévost (Deperdussin—Gnôme 160 horse-power). 31 minutes 22 2/5 seconds. Average speed: 191.2 kilometers (118.5 miles) per hour.
2. E. Védrines (Ponnier—Gnôme 160 horse-power). 32 minutes 28 seconds. Average speed: 184.8 kilometers (114.6 miles) per hour.
3. Gilbert (Deperdussin—Le Rhône 160 horse-power). 33 minutes 45 4/5 seconds. Average speed: 177.9 kilometers (110.3 miles) per hour.
4. Rost (Deperdussin—Gnôme 100 horse-power). 37 minutes 4 seconds. Average speed: 160 kilometers (99.2 miles) per hour.

Height Competition.
Pilot Alone.

1. Parmelin (Deperdussin—Gnôme 80 horse-power). 3,441 meters (11,286 feet).
2. Legagneux (Morane-Saulnier—Gnôme 80 horse-power). 3,409 meters (11,181 feet).
3. Crombez (Deperdussin—Gnôme 80 horse-power). 1,626 meters (5,333 feet).

Pilot and One Passenger.

1. Gilbert (Morane-Saulnier—Le Rhône 160 horse-power). 4,348 meters (14,261 feet).
2. Brindejonc des Moulinais (Morane-Saulnier—Gnôme 80 horse-power). 3,108 meters (10,194 feet).
3. Garros (Morane-Saulnier—Gnôme 80 horse-power). 2,819 meters (9,246 feet).

Pilot and Two Passengers.

1. Moineau (Bréguet—Gnôme 140 horse-power). 1,562 meters (5,123 feet).
2. Espanet (Nieuport—Gnôme 80 horse-power). 1,360 meters (4,460 feet).

Slow Flying Contest.

1. Derome (Bréguet—Salmson 140 horse-power). Speed per hour: 51.48 kilometers (31.9 miles).
2. G. Caudron (Caudron—Anzani 100 horse-power). Speed per hour: 57.36 kilometers (35.5 miles).
3. Legagneux (Morane-Saulnier—Gnôme 80 horse-power). Speed per hour: 58.42 kilometers (36.2 miles).
4. R. Caudron (Caudron—Gnôme 80 horse-power). Speed per hour: 60.64 kilometers (37.5 miles).
5. Gilbert (Morane-Saulnier—Le Rhône 80 horse-power). Speed per hour: 62.46 kilometers (38.7 miles).

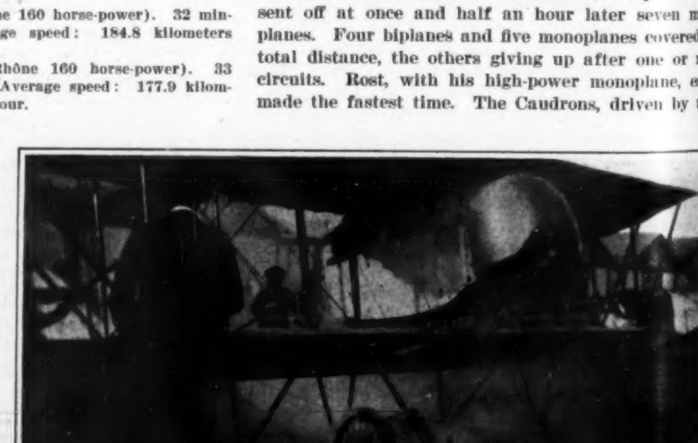
SUNDAY, SEPTEMBER 28TH.

At half past ten Gilbert started forth in an endeavor to beat Perreyon's height record for pilot alone of 5,880 meters (19,286 feet). He did not descend until twelve o'clock, having attained 5,795 meters (19,007 feet). He used oxygen for the last five thousand feet.

The Speed Contest was the converse of the Slow Flying Contest, i. e., in order to qualify, the pilots had first to cover a straight line of two kilometers in both directions at a speed inferior to 65 kilometers (40.3 miles) per hour. The successful pilots then covered three circuits of the course. The winner, Brindejonc des Moulinais, exceeded 120 kilometers (74.4 miles) per hour in this event.

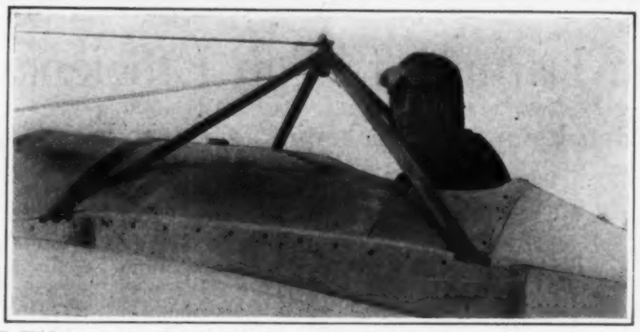
The most interesting feature of the day was the Cross-Country Race over a 30-kilometer (18.6 miles) circuit, covered five times. At 3:30 seven biplanes were sent off at once and half an hour later seven monoplanes. Four biplanes and five monoplanes covered the total distance, the others giving up after one or more circuits. Rost, with his high-power monoplane, easily made the fastest time. The Caudrons, driven by their

Crombez, a Belgian competitor at the Gordon Bennett Cup race, in his Deperdussin, a 160 horse-power Gnôme.



René Caudron (left) starting on single circuit prize run. Gaston Caudron on right. (Caudron—Gnôme 80 horse-power.)

Prevost, the winner of the Gordon Bennett Cup, in his Deperdussin—Gnôme machine.



E. Védrines, second in the Gordon Bennett Cup race. His machine is a Ponnier—Gnôme 160 horse-power.

Gilbert, who came in third at the Gordon Bennett Cup races, Rheims, France.

constructors, put up the best performances in the biplane section.

The Cross-Country Race was the one event of the day appreciated by the public. It was feared that the simultaneous departure of a number of fast machines abreast would cause much air disturbance. This apprehension was not realized owing to the fact that the aeroplanes were placed fifty meters apart. It was extremely difficult to follow the race intelligently, as the machines flew so low that the numbers painted on the wings could not be seen.

The tables of Sunday's performances are given below:

Height Competition.

Pilot Alone.

1. Gilbert (Morane-Saulnier—Le Rhône 80 horse-power). 5,795 meters (19,007 feet).
2. Parmelin (Deperdussin—Gnôme 80 horse-power). 4,276 meters (14,055 feet).
3. Legagneux (Morane-Saulnier—Gnôme 80 horse-power). 2,583 meters (8,472 feet).

Pilot and Two Passengers.

1. Derome (Bréguet—Gnôme 100 horse-power). 2,298 meters (7,537 feet).
2. Maïcon (Caudron—Anzani 100 horse-power). 714 meters (2,342 feet).
3. Vergniault (Goupy—Anzani 100 horse-power). 454 meters (1,489 feet).

Speed Contest.

30 kilometers (18.6 miles).

1. Brindejonc des Moulinais (Morane-Saulnier—Gnôme 80 horse-power). 14 minutes 57 1/5 seconds.
2. Moineau (Bréguet—Gnôme 140 horse-power). 15 minutes 59 4/5 seconds.
3. Legagneux (Morane-Saulnier—Gnôme 80 horse-power). 16 minutes 13 1/5 seconds.
4. Garros (Morane-Saulnier—Gnôme 80 horse-power). 16 minutes 17 4/5 seconds.
5. G. Caudron (Caudron—Anzani 100 horse-power). 18 minutes 9 3/5 seconds.
6. Cailleaux (Goupey—Anzani 80 horse-power). 19 minutes 25 1/5 seconds.

Cross-Country Race.

150 kilometers (93 miles).

MONOPLANES.

1. Rost (Deperdussin—Gnôme 100 horse-power). 1 hour 7 minutes 18 1/5 seconds.
2. Prevost (Deperdussin—Gnôme 80 horse-power). 1 hour 19 minutes 10 3/5 seconds.
3. Parmelin (Deperdussin—Gnôme 80 horse-power). 1 hour 25 minutes 5 2/5 seconds.
4. Espanet (Nieuport—Gnôme 80 horse-power). 1 hour 27 minutes 38 2/5 seconds.
5. Gilbert (Morane-Saulnier—Le Rhône 80 horse-power). 1 hour 31 minutes 15 1/5 seconds.

BIPLANES.

1. R. Caudron (Caudron—Gnôme 80 horse-power). 1 hour 35 minutes 51 seconds.
2. G. Caudron (Caudron—Anzani 100 horse-power). 1 hour 53 minutes 36 seconds.
3. Vergniault (Goupy—Anzani 100 horse-power). 2 hours 43 seconds.
4. Moineau (Bréguet—Gnôme 140 horse-power). 2 hours 9 minutes 42 seconds.

MONDAY, SEPTEMBER 29TH.

Eight o'clock in the morning at the Gare de l'Est, Paris. An enormous crowd is rushing for the train to convey them to Rheims in time to assist at the Gordon Bennett Cup. The aisles of the railway carriages are completely filled by standees who endure the two hours journey without a murmur. At Rheims we make a dash for the train marked "l'Aerodrome." It pulls out after about a dozen of us have clambered aboard, leaving the rest of the trainful on the platform.

As we approach the flying ground we see young Crombez, the Belgian representative who had drawn the first departure, circling the course. He started at ten o'clock. Although his Deperdussin is equipped with a 160 horse-power Gnôme, he is not a likely winner as he plays very safe at the corners. His time for the 200 kilometers (124 miles) is announced as 1 hour 9 minutes 52 seconds, whereat the Frenchmen feel perfectly safe.

Early this morning, several hours before our arrival, Emile Védrines made a trial circuit with his Ponnier, the span of which has been slightly reduced since Saturday, in 2 minutes 58 seconds, which is over eleven seconds better than Prevost's time in the eliminatories. On hearing this the Deperdussin manager became desperate and sent to the factory for new wings for Prevost's mount. These wings, which would support the machine only in ideal weather, such as we are having to-day, are almost perfectly flat on the underside and have a span of less than twenty feet.

The alterations are completed none too soon for Prevost to start at 11:15. The powerful Gnôme springs into action at the very first swing of the tractor and Prevost dashes away toward the grandstands, not taking wing until he speeds up to eighty miles an hour. The flight as seen from the timing pylon is impressive in the extreme. He flies very low, about sixty feet above the ground, but before reaching the pylon he rises to 75 feet, banks steeply, and dives around the corner, fairly shaving the pylon. While we are busy photographing Prevost every time he flashes past close over our heads, M. Henry Deutsch (de la Meurthe), the president of the Aero Club, who has encouraged aeronautics by hundreds of thousands of francs in prizes and by buying dirigibles and aeroplanes, comes up to the group. His arrival temporarily diverts the attention of the photographers from the aviator. When the timer announces that Prevost has completed 100 kilometers in 29 minutes 40 seconds, giving a speed of just over 202 kilometers per hour, we get greatly excited and speculate as to whether the 200 kilometers will be accomplished within the hour. As the twentieth lap is completed our hopes are realized as the time is 59 minutes and 45 3/5 seconds, that is at a speed of 200.803 kilometers per hour (124.5 miles per hour).

On Prevost's return to the hangars he is given a royal welcome and is congratulated by M. Deutsch. A shout goes up for Bechereau, the brilliant designer of the Deperdussin, and we photograph them in front of the celebrated monocoque. Meanwhile Gilbert starts on a similar machine, but with a greater wing spread and another make of motor—Le Rhône. This engine has all valves mechanically operated and uses less gasoline than the Gnôme, though of the same horse-power (160). Owing to the greater prestige of the production of the Brothers Seguin, Le Rhône is very seldom chosen by pilots. Gilbert takes over three minutes for his first round, so is seen to have no chance to wrest the cup from Prevost. The crowd adjourned to the restaurant.

On Gilbert completing the 200 kilometers Emile Védrines starts on the all but hopeless task of beating Prevost's time. He does not equal his own speed of the early morning and is three seconds per lap slower than Prevost. If the Ponnier pilot had started first, however, he would have held the world's records if only for an hour, as he easily surpasses the times set up by Prevost on Saturday. With Védrines' descent comes to a close the last free for all Gordon Bennett Cup we shall probably ever see.

Below are tabulated the figures relating to the Cup:

New World's Speed Records.

Pilot Alone.

Prevost (Deperdussin—Gnôme 160 horse-power).

Rheims, 29th September, 1913.

10 kilometers	(6.2 miles),	2 minutes 56 3/5 seconds.
20 kilometers	(12.4 miles),	5 minutes 54 1/5 seconds.
30 kilometers	(18.6 miles),	8 minutes 52 1/5 seconds.
40 kilometers	(24.8 miles),	11 minutes 50 1/5 seconds.
50 kilometers	(31 miles),	14 minutes 48 1/5 seconds.
100 kilometers	(62 miles),	29 minutes 40 seconds.
150 kilometers	(93 miles),	44 minutes 38 seconds.
200 kilometers	(124 miles),	59 minutes 45 3/5 seconds.

Gordon Bennett Cup, 1913.

200 kilometers (124 miles).

1. Prevost (Deperdussin—Gnôme 160 horse-power). 59 minutes 45 3/5 seconds. Average speed: 200.803 kilometers (124.5 miles) per hour.
2. E. Védrines (Ponnier—Gnôme 160 horse-power). 1 hour 51 2/5 seconds. Average speed: 197.5 kilometers (122.4 miles) per hour.
3. Gilbert (Deperdussin—Le Rhône 160 horse-power). 1 hour 2 minutes 55 2/5 seconds. Average speed: 191.1 kilometers (118.5 miles) per hour.
4. Crombez (Deperdussin—Gnôme 160 horse-power). 1 hour 9 minutes 52 seconds. Average speed: 171.75 kilometers (106.5 miles) per hour.

The afternoon is largely given up to height contests with and without passengers. It is rather interesting to hear what the various competitors have to say on landing. For example: Parmelin (Deperdussin) thought that he had gone up 6,200 meters (20,336 feet), but finds on landing that he misread the barometer, which registers only 4,200 meters. His remarks may better be imagined than described. Legagneux's face is frost covered from being up 4,330 meters (14,202 feet). Some wit asks him: "C'était froid là haut, mon vieux?"

Maïcon (Caudron) descends and explains that his barometer refused to register above 4,000 meters. Gaston Caudron, the young constructor of the machine, demands that the pilot be given another trial. This is indignantly refused by M. Surcouf, the *commissaire sportif*, who maintains that as the entrants must furnish their own barometers they are responsible for their proper working, the officials merely sealing them.

While Emile Védrines is preparing to start in the Single Circuit Prize, his brother Jules, winner of last year's Gordon Bennett, tells us why he did not compete in to-day's race. It seems that the Deperdussin creditors, after the arrest of the head of the firm, refused to fulfill the promise of a machine which the bankrupt had made to him. When at last J. Védrines succeeded in getting a racer the Aero Club would not let him enter the race on the ground that it was too late. This certainly seems rather unjust treatment. The holder of the cup should be allowed to compete. Many protests against the way J. Védrines has been treated have appeared in the press.

Perhaps the most interesting machine on the ground, excluding of course the cup racers, is the new Morane-Saulnier, with overhead plane. The view of the ground from the machine, the design of which is said to have been suggested by Santos-Dumont, is all that can be desired. The fuselage, tail, and chassis are standard. The plane through which projects the mast is placed about eighteen inches over the pilot's head.

The afternoon's performances are given below:

Height Competition.

Pilot Alone.

1. Gilbert (Morane-Saulnier—Le Rhône 80 horse-power). 5,002 meters (16,406 feet).
2. Legagneux (Morane-Saulnier—Gnôme 80 horse-power). 4,330 meters (14,202 feet).

Pilot and One Passenger.

1. Legagneux (Morane-Saulnier—Gnôme 80 horse-power). 2,583 meters (8,572 feet).
2. Vergniault (Goupy—Anzani 100 horse-power). 1,995 meters (6,543 feet).

Pilot and Two Passengers.

1. Gilbert (Morane-Saulnier—Le Rhône 80 horse-power). 3,638 meters (11,932 feet).
2. Bonnier (Nieuport—Gnôme 80 horse-power). 2,284 meters (7,501 feet).
3. Maïcon (Caudron—Anzani 100 horse-power). 2,228 meters (7,308 feet).

Single Circuit Prize.

10 kilometers (6.2 miles).

MONOPLANES.

1. E. Védrines (Ponnier—Gnôme 80 horse-power). 3 minutes 57 3/5 seconds.
2. Espanet (Nieuport—Gnôme 80 horse-power). 4 minutes 27 2/5 seconds.
3. Parmelin (Deperdussin—Gnôme 80 horse-power). 4 minutes 27 3/5 seconds.

BIPLANES.

1. R. Caudron (Caudron—Gnôme 80 horse-power). 5 minutes 11 1/5 seconds.
2. G. Caudron (Caudron—Anzani 100 horse-power). 5 minutes 50 2/5 seconds.

The Rheims meeting, although bringing together a wonderful collection of pilots and machines, and although favored with perfect weather throughout its course, must have proved a failure financially. The general public, having become *blasé* in regard to flying, patronized the meet in comparatively small numbers. Almost everyone of importance in the world of aeronautics, however, who could possibly get to the meet did so. And they were amply rewarded for their trouble. As a spectacle the projectile-like speed of the Gordon Bennett machines is impressive in the extreme. It seems however that no good can come from further encouraging speed *per se* as it is attained by constantly increasing the power of the motor and pitch of the tractor, and cutting the wing surface down to the minimum. Next year it has been decided that every competitor to qualify must execute a flight with and against the wind at a rate of not more than 70 kilometers (43.4 miles) an hour. Even with this restriction it is safe to prophesy that over 150 kilometers (93 miles) an hour will be recorded in the race proper, as Brindejonc des Moulinais after flying at 65 kilometer an hour increased his speed to 120 with the same machine.

Tungsten Lamps of High Efficiency—I*

The Loss of Efficiency of Tungsten Lamps By Blackening of the Bulb, and Methods of Preventing It

By Irving Langmuir

While the transformation of electrical energy into heat or even into mechanical energy has for many years been accomplished with efficiencies well above 90 per cent, the artificial production of light has been notoriously inefficient.

The first carbon incandescent lamps had efficiencies of five to six watts per mean horizontal candle, but were gradually improved over a long period of years to about 3.1 watts per candle, until finally by the use of the metalized filament an efficiency of 2.5 watts per candle was reached commercially. Since the introduction of the metalized carbon filament, progress with other types of lamps has been comparatively rapid, and at the present time the most efficient commercial incandescent lamp, the lamp with a tungsten filament, has an efficiency from one to one and a quarter watts per candle in the ordinary sizes.

Notwithstanding this decided improvement, we are still far from the theoretical maximum of efficiency that would be attained if all the energy of an electric circuit were converted into visible light. Drysdale has shown that perfect efficiency for the production of white light would be about 0.10 watt per candle, whereas with the production of a monochromatic yellow-green light, the efficiency would reach as high as 0.06 watt per candle.

The luminous efficiency of the ordinary tungsten lamp is therefore not better than about 6 to 10 per cent.

The causes which have made it necessary to operate tungsten lamps at such relatively low efficiencies as one watt per candle have been little understood. It seemed, therefore, that an investigation of the phenomena occurring in tungsten lamps, carried out with a view of reaching a clear understanding of the causes of the failure of the lamps, might possibly open the way to the discovery of methods by which the efficiency could be greatly improved.

The present paper is a description of some experimental and theoretical work, extending over a period of many years, which has now resulted in the production of a new type of tungsten lamp; a lamp which will give a life of more than 1000 hours, at an efficiency in the neighborhood of 0.50 watt per candle.

INVESTIGATION OF CAUSE OF FAILURE OF ORDINARY TUNGSTEN LAMPS.

Ordinary tungsten lamps fail, in general, in one of two ways: namely, either by breakage of the filaments, or by blackening of the bulb. In ordinary practise the useful life of the lamp is considered to be the time which the lamp burns before its candle-power has fallen to 80 per cent of its original value, or until the filament breaks, in case this occurs while the candle-power is still above 80 per cent.

The breakage of the filament was a very serious factor in the early tungsten lamps, as the filament material was extremely brittle. This difficulty has now been overcome by the production of ductile tungsten wire and by better methods of mounting the wire in the bulbs, so that lamps can now be made which are so strong that a blow is more likely to break the bulb than the filament.

The life of tungsten lamps is therefore at present practically determined by the rate at which the candle-power decreases. The main cause of this decrease is evident by mere inspection of a lamp which has run several hundred hours. It is due simply to the blackening of the inner surface of the bulb.

The cause of this blackening was the subject of much speculation. The prevalent opinion seemed to be that in a normally operated lamp it was due to disintegration of the filament, caused by the presence of traces of residual gas, whereas in lamps run at much more than their rated voltage it was perhaps caused by evaporation. Others, however, considered it due to leakage currents of electricity (Edison effect) across the space between the positive and negative end of the filament. Still others were of the opinion that the blackening of the bulb was due primarily to evaporation of the filament.

In the manufacture of carbon incandescent lamps, it had been found necessary to use a relatively high vacuum, as otherwise the lamps were found to have a very short life. That is, the bulbs blackened rapidly or discharges occurred between the two ends of the filament, finally resulting in the formation of an arc which destroyed the lamp. Various attempts had been made to prevent the blackening by the introduction of gases at various pressures in the lamp. For example, Edison proposed introducing nitrogen or cyanogen at relatively high pressures into lamp bulbs, for the purpose of preventing the electric discharge between the positive and the negative end of the filament. In this way he hoped to prevent blackening. These attempts, however, were completely unsuccessful, and it can be readily shown in the case of a carbon lamp, run at say 3 watts per candle and containing nitrogen at atmospheric pressure, that the filament loses weight more rapidly than when run in a vacuum at the same efficiency.

In the commercial production of lamps it was found necessary at first to use mercury pumps for the exhaustion of the lamps; mechanical pumps were not good enough. Later it was found possible to obtain a sufficiently good vacuum with mechanical pumps, which by that time had been considerably improved, by introducing red phosphorus into the lamp just before sealing off, and at the same time heating the filament to a much higher temperature than that at which it was to run normally. It should be pointed out that not only was it necessary to use some such special method of exhaust, but in order to obtain lamps of good life, the bulbs themselves had to be heated to a high temperature during the exhaust, in order to drive off any gases condensed on the surface of the glass. It is interesting to notice that the lamp manufacturers had adopted these precautions in obtaining a high vacuum long before the necessity for them was realized by most scientific investigators engaged in work with high vacuum.

When the lamp factories began the manufacture of tungsten lamps, they found that much greater precautions were needed in the exhaustion of these lamps than had been necessary for the ordinary carbon lamps, and many improvements in the methods of exhaustion were adopted.

Unless all this care was taken to obtain the best possible vacuum, there were striking evidences of the presence of residual gas in the lamps after they were sealed off.

Various attempts to improve the life of lamps by obtaining a better vacuum than usual had not been very successful. This failure, however, could not be taken as proof that a better vacuum would not improve the life. In the first place, it had been found that the vacuum of a lamp gradually improved after sealing off ("clean-up" effect), the pressure finally reaching a value probably lower than that directly obtainable by any of the well known methods of exhausting. Yet even where we had pressures lower than would be indicated by the most sensitive vacuum gages, we often had clear indications that the blackening of the bulb was due to imperfect exhaust. It seemed quite possible, therefore, that there might remain, in lamps, minute traces of some gas or vapor which we had not yet learned to remove by our usual methods of exhaust. This residual gas might easily be the cause of the gradual blackening of the bulbs.

Since the pressures were too low to measure, we had no way of definitely knowing whether one method of exhaust was better than another, so that any failure to improve the life by a new method of exhaust might simply mean that the vacuum had not been improved.

It seemed, therefore, that the question as to whether a better vacuum would give a better lamp could only be settled by a direct investigation of the cause of the blackening.

Two lines of attack were decided upon:

1. Study of the sources of gas within a lamp.
2. Effects produced in lamps by various gases.

SOURCE OF GAS WITHIN THE LAMP.

There are four sources of gas within the lamp bulb: first, residual gas left by evacuation; second, gas given off by the filament; third, gas from the lead-in wires or the anchors; and fourth, the gas given off by the glass.

1. *Residual Gas.* The mechanical pumps ordinarily used in exhausting lamps produce a vacuum of about 0.001 millimeter, according to the McLeod gage. This is probably about the pressure of the non-condensible gases left in the lamp. Besides this, however, there must be some water vapor and oil vapor, and if the filament has been lighted during the exhaust, as is usually the case, there will be some carbon monoxide, carbon dioxide, and hydrogen produced by the action of the filament on the vapors. Probably most of these gases are nearly completely removed, or precipitated on the walls of the bulb, by the clean-up that occurs when the phosphorus is volatilized into the lamp and a blue glow made to occur. The final pressure, just after sealing off, is usually in the neighborhood of 0.001 millimeter or less.

2. *Gas from the Filament.* The prevalent opinion, as expressed generally in scientific literature, is that metals when heated to very high temperature in vacuum, evolve very large quantities of gas. For example, in a recent article, Prof. J. J. Thomson (*Nature*, 91, p. 335, 1913) says: "Belloc, who has recently published some interesting experiments on this subject, after spending about six months in a fruitless attempt to get a piece of iron in a state in which it would no longer give off gas when heated, came to the conclusion that, for practical purposes, a piece of iron must be regarded as an inexhaustible reservoir of gas." Thomson's own experience is quite similar.

The first few experiments on the gases evolved from the filament of a tungsten lamp also seemed to show the presence of inexhaustible supplies of gas within the filament. Later work proved, however, that this gas was not actually evolved from the filament, but was produced from the decomposition by the filament of water vapor or hydrocarbon vapors present at extremely low pressure in the bulbs. It was finally found that with small filaments, such as are used in lamps, the gas evolved by heating is not more than from three to ten times the volume of the filament. By thoroughly cleaning the surface of the wire before heating, the amount of gas is usually not over half as great. The surprising fact was observed that at least 90 per cent of the gas was given off within a few seconds on first heating the wire to a temperature exceeding 1500 deg. Cent. At a temperature below 1,200 deg. however, the gas is given off only very slowly, if at all. The gas consists of about 70 to 80 per cent carbon monoxide, the remainder being mostly hydrogen and carbon dioxide. The total amount of gas evolved from the filament of a 40-watt lamp, if liberated in the lamp after sealing off, would produce a pressure of from 0.006 to 0.02 millimeter.

3. *Gas from Lead-in Wires and Anchors.* In many of the larger lamps, where the leads or anchors become very hot, there are often clear indications that the gas evolved from this source has a marked effect on the life, particularly on the tendency to arc across during aging. In the experimental lamps made with small sizes of wire, the quantities of gas obtained from this source were found to be too small to measure.

4. *Gas from the Bulb.* On heating bulbs of 40-watt lamps for three hours to a temperature of 200 deg. Cent., after having dried out the bulbs at room temperature for 24 hours by exposure in a good vacuum to a tube immersed in liquid air, the following quantities of gas were given off:

200 cubic millimeters water vapor.
5 cubic millimeters carbon dioxide.
2 cubic millimeters nitrogen.

These are the quantities of gas, liberated by the heating, expressed in cubic millimeters at room temperature and atmospheric pressure.

By raising the temperature of the bulbs from 200 deg. to 350 deg., an additional quantity of water vapor was obtained, so that the total now became.

300 cubic millimeters water vapor.
20 cubic millimeters carbon dioxide.
4 cubic millimeters nitrogen.

A subsequent heating of the bulbs to 500 deg. Cent. caused the total amount of gas evolved to increase up to

450 cubic millimeters water vapor.
30 cubic millimeters carbon dioxide.
5 cubic millimeters nitrogen.

At each temperature the gas stopped coming off the glass after a half hour of heating, only to begin again whenever the temperature was raised to a higher value than that to which the bulb had been previously heated.

It therefore seems that even by heating the bulb to 500 deg. not all of the water vapor can be removed, but it does seem probable that after this treatment the amount of water vapor that can come off a bulb at ordinary temperatures must be extremely small.

This study of the origin of the gases within a lamp thus led to the following important conclusion:

The amounts of residual gas, together with all the gas that is given off by the filament and its supports, are quite insignificant as compared with the gas on the inner surface of the bulb. Furthermore, the great difficulty of completely removing the gases from the glass makes this source particularly troublesome in incandescent lamps. We see that the gases likely to be present or given off in an exhausted lamp are, in the probable order of their importance: water vapor, carbon dioxide, hydrocarbon vapors, hydrogen, carbon monoxide, nitrogen and, when phosphorus is used, various phosphorus compounds.

*A paper presented at the 286th meeting of the American Institute of Electrical Engineers, New York, October 10th, 1913.

EFFECTS PRODUCED IN LAMPS BY VARIOUS GASES.

Hydrogen. This gas cleans up (disappears) in a lamp bulb in four distinct ways. Relatively large quantities (20 to 50 cubic millimeters) of hydrogen are driven on to the bulb when the filament is at relatively low temperature (1,500 deg. or more). This hydrogen is particularly active chemically (atomic hydrogen) and will react even at room temperature with many reducible substances. Moderate heating of the bulb will cause a large part of it to escape from the glass again. Since water vapor in the bulb is decomposed by the filament to form hydrogen and an oxide of tungsten, there is nearly always a considerable amount of active hydrogen stored up on the bulb after the lamp has been running some time.

The amount of heat carried away from a filament by hydrogen at low pressures, say 0.001 millimeter, although many times greater than with any other gas, was found to be entirely negligible compared with the heat radiated from the filament. The cooling effect of such pressures of gas, therefore, has no appreciable effect on the life of lamps, even though, as is usually the case, the lamps are set up at a given efficiency.

Dry hydrogen in lamps was never found to have the slightest tendency to produce blackening of the bulbs. That is, the bulbs never blackened more rapidly than if the filament were run at the same temperature in a vacuum. Subsequent experiments have proved that this is true from low pressures up to atmospheric pressure.

Oxygen. At all temperatures above 1,000 deg. this gas reacts with tungsten to form the yellow oxide WO_3, no matter how low the pressure of the oxygen may be. The oxide distills off the filament and deposits on the bulb, but owing to its light color the deposit is invisible when the amount of oxygen is less than 100 to 200 cubic millimeters. Oxygen therefore never produces blackening of the bulb.

Nitrogen. There are three ways in which this gas cleans up in a lamp, each being an exceptionally interesting phenomenon in itself. With voltages above 40 volts and pressures above 0.001 millimeter the nitrogen cleans up provided the filament temperature exceeds 2,000 deg. and causes an attack of the negative end of the filament, producing a brown deposit of tungsten nitride, WN_2, on the bulb. Except where the amount of nitrogen that cleans up is much larger than could possibly be present in an ordinary lamp this gas never causes any discoloration of the bulb.

Carbon Monoxide. This gas behaves almost exactly like nitrogen. At low pressures it never produces perceptible blackening of the bulb, although at higher pressures it may slowly give a slight deposit of carbon under certain conditions. The results, however, clearly indicated that traces of carbon monoxide such as might exist in lamps could not be responsible for the blackening.

Carbon Dioxide. This gas attacks the filament and produces carbon monoxide and an oxide of tungsten, without producing any perceptible blackening.

Water Vapor. Even very low pressures of water vapor react with the tungsten filament in a lamp to produce hydrogen, and cause rapid blackening of the bulb. Thus a lamp made up with a side tube containing a little water which is kept cooled by a freezing mixture of solid carbon dioxide and acetone (—78 deg. Cent.) will blacken very rapidly when running at normal efficiency, although the vapor pressure of water at this temperature is only about 0.0004 millimeter.

The fact that lamps exhausted at low temperature (say 100 to 200 deg.) blacken so rapidly during life, together with the fact that water vapor is the principal gas removed from the bulb by heating, indicate that the water vapor is responsible for the short life under these conditions.

It is rather surprising that water vapor should have such a marked effect when either of its constituents, hydrogen or oxygen, acting alone, produces no blackening.

The explanation of the behavior of the water vapor seems to be as follows:

The water vapor coming into contact with the filament is decomposed, the oxygen combining with the tungsten and the hydrogen being evolved. The oxide distills to the bulb, where it is subsequently reduced to metallic tungsten by atomic hydrogen given off by the filament, water vapor being simultaneously produced. The action can thus repeat itself indefinitely with a limited quantity of water vapor.

Several experiments indicated that the amount of tungsten that was carried from the filament to the bulb was often many times greater than the chemical equivalent of the hydrogen produced, so the deposit on the bulb could not well be formed by the simple attack of the filament by water vapor.

Another experiment demonstrated that even the yellow oxide, WO_3, could be reduced at room temperature by atomic hydrogen. A filament was heated in a well exhausted bulb containing a low pressure of oxygen; this gave an invisible deposit of the yellow oxide on the bulb. The remaining oxygen was pumped out and dry hydrogen was admitted. The filament was now lighted to a temperature (2,000 deg. K.) so low that it could not possibly produce blackening under ordinary conditions. In a short time the bulb became distinctly dark, thus indicating a reduction of the oxide by the active hydrogen. Further treatment in hydrogen failed to produce any further darkening, showing that the oxide could only be reduced superficially.

Mercury Vapor. Contrary to earlier experiments, it was found that mercury vapor in a lamp did not cause blackening if the voltage was low enough so that no serious Edison effect occurred.

ATTEMPTS TO ELIMINATE WATER VAPOR.

This study of the effects produced by various gases led to the conclusion that if the blackening of bulbs of ordinary lamps was caused by imperfect vacuum, then it must be due to water vapor and the further removal of water vapor would markedly increase the life of the lamps. The problem of improving the efficiency of lamps thus assumed more definite form.

Lamps were exhausted in a special vacuum oven, so that the temperature of the bulb could be raised during exhaust to a temperature about 100 deg. higher than that otherwise attainable. A good mercury pump was used and care was taken to remove the last traces of mercury vapor, water vapor and carbon dioxide, by placing between the lamp and the pump a trap immersed in liquid air. The lamps were exhausted from one to three hours under these conditions. The filaments were heated to high incandescence to drive off gas. The lamps were sealed off when the pressure by the McLeod gage read about 0.00005 millimeter. These lamps were put on life test and compared with other lamps made under factory conditions.

The unexpected result of this work was that the life of the lamps exhausted with all these precautions was not materially better than the *best* of the lamps made regularly in the factory. The life of the lamps could certainly not be improved on the average by more than 20 per cent by such methods.

Very special methods of exhaust did not improve the life of the lamp above that of an ordinary lamp run under normal conditions, but they did make it possible for a lamp to run with the bulb at a high temperature without serious impairment of its life. This seemed to demonstrate that even the complete removal of water vapor from the lamp bulb would not lead to a very radical improvement in the life of the lamp, although the presence of minute traces of water vapor certainly did cause a marked decrease in the life.

The conclusion to be drawn from all of the foregoing work is that the blackening of the bulbs of ordinary well made and well exhausted lamps is *not* caused by imperfect vacuum.

Among all the causes of the blackening that have been suggested, the only one that remains is evaporation of the filament.

EVAPORATION OF TUNGSTEN.

To test out whether or not this was the correct explanation, many experiments were undertaken to determine the rate of loss of weight of tungsten filaments when run at various temperatures in lamps. It was found that in lamps with filaments run at the same temperature the loss in weight was proportional to the surface of the filament and independent of the size of the bulb. The temperature coefficient of the rate of loss of weight was extremely high, as would be expected if it were proportional to vapor pressure of the metal.

Furthermore, the actual measurements at various temperatures agreed remarkably well with the rational formula for vapor pressure:

$$\log P = A - \frac{B}{T} C \log T$$

Experiments with lamps exhausted at a low temperature have shown that the temperature coefficient of the rate of blackening is much lower than in well exhausted lamps. Thus, lamps exhausted at 100 deg. and run at say 5 watts per candle, often blacken nearly as quickly as similar lamps run at 2 watts per candle, although the rate of evaporation in a good vacuum would be very different. This serves to show clearly the radical difference between the two kinds of blackening.

METHODS OF PREVENTING THE BLACKENING OF BULBS.

Having now shown that the blackening of ordinary tungsten lamps is caused by evaporation of the filament, the problem of increasing the efficiency of the lamps becomes a very definite one.

Introduction of Gases at High Pressure. Although in the past it has usually been found that the presence of a high pressure of gas causes an increase in the rate of disintegration of a heated metal, yet if we know, as we now do in the case of tungsten, that the phenomenon is simply one of evaporation, then we have every reason to believe that the presence of a chemically inert gas will reduce this evaporation. We have seen that low pressures of gases (except water vapor and argon) do not produce any perceptible blackening of the bulb, and therefore produce no disintegration in the ordinary sense. Most gases react chemically with tungsten at high temperature, but hydrogen, nitrogen, argon, and mercury vapor seem to be chemically inert toward it.

In the manufacture of tungsten filaments it was for a ong time the practice to sinter the filament thoroughly by heating it to a high temperature in hydrogen or in a mixture of nitrogen and hydrogen. If care were taken to avoid air or moisture in the "forming gas" the filaments would stand heating for a long time in these gases, which indicated that they were at least relatively chemically inert.

Whether the loss in weight at a given temperature was actually greater or less than in vacuum could not be determined from these rough observations. To test this out, a lamp was made and filled with carefully dried and purified hydrogen at atmospheric pressure. The filament was run at the same temperature as that of lamps running at one watt per candle. The heat loss from the filament by convection was so serious that actually 17 watts per candle were required to maintain the filament at this temperature. This lamp, however, ran for more than 360 hours without showing any blackening of the bulb, or any greater loss of material from the filament than would have been the case in vacuum at the same temperature. This result was very striking, as the bulb was running so hot that the life of a filament in vacuum, in a bulb at the same temperature, would have been very short indeed. Subsequent experiments fully confirmed the first one, and showed that even in the presence of hydrogen at atmospheric pressure, the loss of weight of tungsten was much less than in vacuum. The loss of heat, however, was so great that it would be entirely impracticable to make a lamp with the tungsten filament in hydrogen at high pressure.

Subsequent experiments showed, however, that the heat conductivity of hydrogen at very high temperature was abnormally great—much greater than would be expected from the ratio of its heat conductivity to that of other gases at room temperature. This is due to the fact that at high temperatures hydrogen becomes dissociated into atoms.

Experiments were then tried in nitrogen at atmospheric pressure. Nitrogen was found to be entirely inert towards the tungsten, and to conduct so little heat that with a fairly large diameter filament the efficiency was as high as 0.24 watts per candle, at a temperature close to the melting point of tungsten. The rate of evaporation was found to be much less than in vacuum.

The next point to be determined was whether the decrease in evaporation was sufficient to offset the heat lost by convection. Because of the presence of the gas, the temperature of the filament was run considerably higher than in vacuum, in order to obtain the same efficiency. Whether or not the rate of evaporation in gas at this *higher temperature* would be less than the rate of evaporation in vacuum at the same efficiency, is a point to be determined only be experiment.

A careful study was therefore undertaken of the laws of heat convection from filaments at high temperature in various gases, since the knowledge on this subject was extremely meager. Experiments were made with platinum wires in air, with platinum wires in carbon dioxide and in hydrogen, and with tungsten wires in hydrogen, nitrogen and mercury vapor.

According to the formulæ developed in the course of this work, the heat loss from wires of any size in any of the ordinary gases at any temperature could be calculated. In this way it was found that the loss of efficiency (at constant temperature) due to the introduction of a gas at high pressure is very much greater for filaments of small size, than for the larger ones, so that with wires of the sizes ordinarily used in lamps the temperature would have to be raised excessively in order to obtain an efficiency of even one watt per candle.

The advantages of a large diameter filament can be practically obtained by coiling a smaller wire into a tightly wound helix.

PREVENTION OF BLACKENING.

Changing Location of the Deposit. In lamps with a very high vacuum, the atoms of tungsten as they are given off from the filament by evaporation, travel in straight lines until they strike the bulb. As they are electrically uncharged (this has been demonstrated by experiment), the field produced by the filaments has no influence on the location of the deposit. Since the light from the filament also travels in straight lines, according to similar laws, it follows that in a high vacuum the deposit always collects most on those portions of the bulb where the strongest light passes through the glass.

In an imperfect vacuum, especially in the presence of argon, the tungsten atoms tend to become negatively charged and deposit on the bulb very irregularly.

With pressures of nitrogen less than 50 millimeters, the brown deposit of nitride is distributed over the bulb in much the same way as the tungsten deposit in ordinary lamps. At higher pressures than this the effects of convection currents become apparent. At atmospheric pressure this effect is very striking.

(*To be continued.*)

Fig. 1.—Stela C, Quirigua, Honduras, from Mandsley.

Fig. 2.—Turtle, Quirigua, Honduras, from Mandsley.

Fig. 3.—Stela F, Quirigua, Honduras, from Mandsley.

Stone Monuments—II*

Their Relation to History and Geography

By J. Walter Fewkes

Concluded from Scientific American Suplplement No. 1972, Page 251, October 18, 1913

Only a few of the more advanced people of America show evidences of the megalithic phase of culture, but the races dwelling on the Cordilleras of South America and those inhabiting the lowlands of Central America were in this stage of cultural development before the discovery of America by Europeans. The best examples of megaliths occur in Peru, Colombia, Guatemala, Honduras, Mexico, and Yucatan, in all of which countries there are fine examples of both monoliths and colossi. They often bear glyphs or calendar symbols, which are characteristic of the New World as the Egyptian hieroglyphs are of the country bordering the Nile. No satisfactory evidence has yet been brought forward that phonetic writing arose independently on the American continent. The Indians of the territory of the present United States never developed a megalithic stage, although sporadic instances of natural rocks which have a religious rôle might be mentioned.

With few exceptions where we find monoliths and colossi, cyclopean walls likewise occur, evidently intended to express the same consciousness of power. This is particularly true of the Incas and pre-Incan races who handled the largest blocks of heavy stone and fitted them together with an accuracy that has astonished everyone from the time of their Spanish conquerors to the present.

We find in various parts of tropical America circles and alignments of monoliths recalling menhirs or cromlechs of the Old World, and called Indian corrals and ball courts. One of the largest and best known of these described by Schomburgk, near San Juan de Maguana in Hayti, was formed of granite stones each from 30 to 50 pounds in weight and arranged in a ring measuring 2,776 feet in circumference. In the center of this dolmen was a rock over 5 feet high supposed to be an idol. Peruvian and Bolivian "sun-circles," are structurally comparable with stone circles in Taumalipas and Vera Cruz, except that they approach the circular rather than rectangular forms.

As Egypt is the native land of the Old World obelisk and colossus, so Central America is the home of the colossi and commemorative monoliths of the New. The American counterpart of Egyptian obelisks are the so-called stelæ of Tikal, Quirigua, Ocosingo, Copan, and the ruins of the Ucimacintla valley, in Honduras.

According to Mr. C. P. Bowditch:

"Monoliths are scattered all over the northern and eastern slopes of the Cordilleras as they run through the State of Chiapas in Mexico, and through the Republic of Guatemala into Honduras . . . and in the whole extent of the peninsula of Yucatan. . . . The monoliths may be roughly divided into two kinds, according to their shape. One kind (called stela, plural stelae) is tall, measuring in one case 28 feet in height, while they are not over 4 feet in width or depth. The others are low and take various forms, being square, oblong, or round as a rule, though some are carved in the shape of an uncouth animal.

The stelæ of Copan and other related Central American ruins have carved upon them representations of men or women wearing symbolic ceremonial paraphernalia, and like the Egyptian statues of Rameses are not intended for divinities but represent priests wearing symbols or headdresses characteristic of gods. These American monoliths or stelæ, like Egyptian obelisks, bear vertical rows of lines of hieroglyphs; they generally stand in front of temple mounds or on ceremonial plazas, in much the same relative position as obelisks, indicating by the position, general form, and accompanying glyphs that they are both memorial and religious in character.

The great animal effigies of the Lake of Menagua in Nicaragua, described by Dr. Carl Bovallius, belong to the group of monoliths architectural rather than religious in character, being intermediate between unworked monoliths and colossi. Perhaps the best known Aztec megalithic statue is that called Huitzilopochtli, the God of War, which Mr. Payne, with good reason, identifies as the Corn Snake goddess, a colossal representation of an effigy made of corn stalks used in ceremonial dances. The great stone tiger found a short time ago in excavations made in a street back of the cathedral near where the old temple of the Aztecs once stood in Mexico City, is a colossus, and the giant serpent's head, part of the ancient wall of the temple now set in the foundation of an adjacent modern building, belongs to the same category.

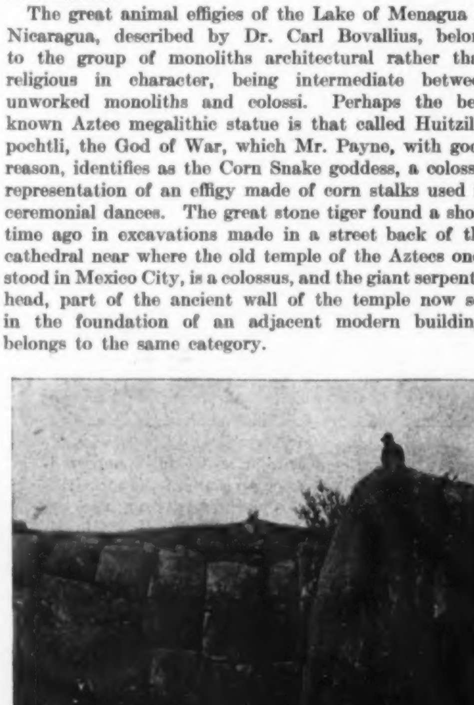


Fig. 4.—Colossal wall, Cuzco, Peru, from Squier.

No colossi have been reported from the Gulf coast north of Taumalipas, but the pillar stones in rude human form, like those of the Huastecs, occur from Cuba to St. Vincent, West Indies, showing the presence of the monolithic feeling among the former people of the Antilles, as well as the Spanish Main.

Our studies of megaliths in America would be incomplete were we to neglect the cyclopean buildings of Peru, with monoliths so remarkable that they have excited the imagination of all travelers. Considerable literature exists regarding these structures; the impression after reading descriptions of them is of great wonder at the magnitude of these buildings.

Mr. E. G. Squier has figured and described one of these monuments which he aptly designates the "American Stonehenge":

"The temple seems to me to be the most ancient of all the distinctive monuments of Tiahuanaco. The stones defining it are rough and frayed by time. The walls between its rude pilasters were of uncut stones; and although it contains the most elaborate single monument among the ruins, and notwithstanding the erect stones constituting its portal are the most striking of their kind, it nevertheless has palpable signs of age, and an air of antiquity which we discover in none of its kindred monuments. Of course, its broad area was never roofed in, whatever may have been the case with smaller, interior buildings no longer traceable. We must rank it, therefore, with those vast open temples (for of its sacred purpose we can scarcely have a doubt) of which Stonehenge and Avebury, in England, are examples, and which we find in Brittany, in Denmark, in Assyria and on the steppes of Tartary."

The monolithic gateway of Tiahuanaco, Bolivia, is the best known megalith of South America. Squier says:

"We must imagine a block of stone, somewhat broken and defaced on its edges, but originally cut with precision, 13 feet 5 inches long, 7 feet 2 inches high above ground, and 18 inches thick. Through its center is cut a doorway, 4 feet 6 inches high and 2 feet 9 inches wide. Above this doorway and as it now stands on its south-east side or front, are four lines of sculpture in low relief, like the Egyptian plain sculptures, and a central figure immediately over the doorway sculptured in high relief. On the reverse we find the doorway surrounded by friezes or cornices, and above it on each side two small niches, below which, also on either side, is a single larger niche. The stone itself is a dark and exceedingly hard trachyte. It is faced with a precision that no skill can excel."

Among other examples of South American structures illustrating South American monoliths may be mentioned the sun-circles (*intihuatana*), first described by Squier, of Sillustani and the stone pillars of Hatuncolla, the latter decorated with figures of serpents, lizards, frogs, and elaborate geometrical designs. The sun-circles consist of rings of well-fitted flat stones forming a platform, on the inner edge of which are erect uncut stones arranged in ring shape, while in the enclosure thus formed are other upright stones that also show no sign of tools. These sun-circles reminded Squier of megalithic monuments of England and northern Europe, and in certain particulars they recall to my mind the batey or ball courts of the West Indies, Mexico, and Central America.

In the limited time available only a few of many megalithic structures in Peru can be instanced; the list might be much enlarged by the addition of monolithic doorways and other examples, but these suffice to show that the erection of megaliths attained a high development in South as in Central America. A people where this power was so highly developed naturally built stones of great size into their temples and fortresses as that of Sacsahuaman, which Squier regarded the greatest specimen of cyclopean style in America. The measurements of the size of the corner-stones of buildings at Cuzco, or salient angles of the component stones of the trinchera-like walls of this fortress are extraordinary; one of the foundation stones is said, by Squier, to be "27 feet high, 14 broad, and 12 in thickness."

* Abridged from the presidential address before Anthropological Society of Washington, and published in the Smithsonian *Miscellaneous Collections*.

Fig. 5.—Monolithic gateway, Tiahuanaco, Bolivia, from Stübel and Uhle.

Fig. 6.—Monolithic gateway, Tiahuanaco, Bolivia, from Stübel and Uhle.

The plain near Acora, Peru, is covered with many rude monuments in the forms of circles and rectangles constructed of unwrought upright stones, which Squier finds "almost identical" with cromlechs of Europe, and "might be transferred to Brittany or Wales and pass for structures contemporary with the thousand rude monuments of antiquity found in those regions."

The long, and at times seemingly tortuous, trail we have followed has led the writer to the following generalization. Although the megaliths are among the oldest buildings or architectural structures erected by man, all, from the simplest to the most complex, belong to a series wholly distinct from that including habitations of the living. From the rude uncut monoliths to the perfection of architectural expression, the Parthenon, there are many and varied forms of religious edifices, temples, and shrines, but none of them were erected primarily as human residences. Man has never built as good a dwelling for himself as for his ancestors or gods. Man's noblest architectural efforts are not for abodes for himself while living, but in response to a striving for ideals far higher than personal vanity or shelter for his family. Even dwellings of despots shrink into insignificance in comparison with the creations of a race influenced by the highest religious feeling. The habitations of the builders of the great temples whose ruins astound us by their magnitude, are forgotten; they do not belong in the same series as the megaliths we have studied; they were built by individuals for shelter and personal comfort. Megalithic monuments are expressions of a community feeling influencing man to co-operate for ideals higher than self and should be judged by a very different standard. Temples are not modified human dwellings, but evolutions of the same religious ideal which led man in early times to erect monoliths and colossi.

After what has been said on the geographical distribution of monoliths we may dismiss without serious consideration the theory that they were made by one and the same great race. Equally unattractive is the specious corollary that migrations of culture, save within limits, can be traced by them.

They represent a phase of religious thought, of spontaneous origin almost identically expressed. Commonly associated with tombs or burial places, they are almost universally connected with the cult of the dead. They are both cultural and religious, or expressions of a phase of racial feeling at a time before the two had been differentiated.

In closing it is well to emphasize the main object of the preceding pages and to point out that monoliths and colossi are geographically widespread and not limited to one continent or to any one race of man.

They express a profound racial self-consciousness of power amounting to a religious feeling; incidentally as in arts, institutions, beliefs, and languages, environment furnishes material for or modifies the expression of this consciousness and stimulates endeavor, but culture is due to mental efforts to overcome environment by invention.

Hoisting in Place a Giant Girder

By O. W. Brown

A GIANT steel girder, which is said to be the largest ever made in this country, and which is to form a part of the overhead structure for the Boston and Maine railroad in its elimination of the grades at Lynn, Mass., has been swung into place with the aid of a donkey engine and four men. The girder is 139 feet long and weighs 180 tons, yet it was lifted from three flat cars on which it rested and put in place in 1 hour and 58 minutes.

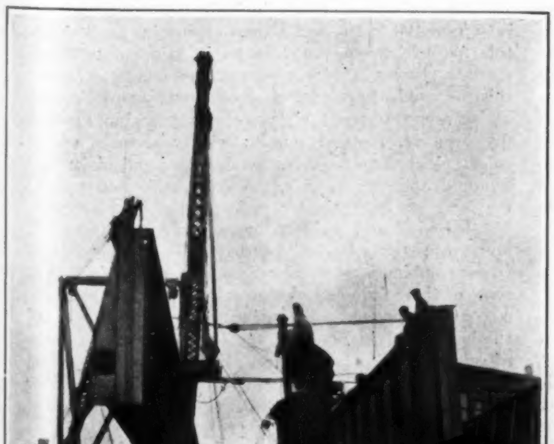
Three other girders which are to be mates of the giant have also been put in place, but none of them compare in length or weight with the 180-tonner. The big one is on the western side of Central avenue, extending from the head of Railroad avenue across Central avenue to the foot of Union street. The ease with which it was handled by the workmen was surprising to the 1,500 people who missed a night's sleep to witness the work of putting it in place.

When the resident engineer for the Boston and Maine railroad, in charge of the grade crossing work at Lynn, studied his blue print drawnings, he found that the tracks of the Bay State Street Railway Company were located where he wished to erect pillars to support the four steel girders to hold the tracks of the Boston and Maine Railroad across Central Square. He doubted if it would be possible to construct a girder of the length necessary to reach across the square without piers. The company approached with this problem felt confident that they would be able to construct such a girder and one of their consulting engineers visited Lynn and after looking over the location for the girder declared that his company could build the girder, but doubted if it could be put in place after its construction.

The girder took up the greater part of three freight cars on its way from the foundry to Lynn. A double hoisting engine was sent to that city along with the girder, and a derrick with a steel crane 225 feet long also was supplied. At one o'clock in the morning the grippers on both cranes were fastened to the girder and the donkey engines commenced their work. There were frequent pauses by the engines as the four workmen—two on each end,—steadied and guided the cranes, and at 1.58 A.M. the girder was being fastened to the fishplates on concrete work 190 feet apart.

What was most surprising to both the contractors and railroad men was that during all the time the girder was in the air there seemed to be no exertion on the part of the men in guiding the huge piece of steel just where it should go.

Stretched along Central Square, across the street-level tracks of the Boston and Maine Railroad, were the trolley wires of the Bay State Street Railway, the Western Union, Postal and telephone company wires. They were not disturbed while the work was going on and as soon as the girder was in place they were fastened underneath it.



The 180-ton girder just before it has swung into place.

The great girder was mounted upon three freight cars on its journey by rail.

Coloring Non-Ferrous Metals and Alloys*

Cleaning Work; Receipts for Producing Different Colors; Oxidizing; Mottling

By E. F. Lake

MAN is so much a product of nature that mere light and shade, or white and black, are only pleasing for a time. To fully satisfy his natural desires, man's vision must be stimulated by views of different colors and various combinations thereof. To look upon one color continuously is one of the most tiresome things he can do, as it affects his entire nervous system. This has led to the coloring of metals, and to producing many beautiful effects in place of the natural color of the metal which may become repulsive from being seen too frequently.

In thickly inhabited sections a great deal of coal gas is burned. More or less of the products of combustion together with the gases arising from the manufacture of other materials stay in the atmosphere and give to brass and bronze objects a dark, dirty color by attacking their surfaces. The oxygen and moisture in the atmosphere also give these metals or alloys a disagreeable color. Hence coloring or coating is also resorted to for the purpose of enhancing and preserving the original beauty of the metal. Sometimes rich and beautiful browns and greens are produced on copper alloys that have been subjected to atmospheric conditions for years. Therefore these conditions have been studied and chemical means have been found for producing the colors quickly and on a commercial scale.

Copper is more susceptible to coloring processes and materials than any of the other metals, and hence the alloys containing large percentages of copper are readily given various shades of the yellow, brown, red, blue and purple colors and also black. Alloys with smaller percentages of copper, or none at all, can be given various colors, but not as easily as if copper were the principal ingredient, and the higher the copper content, the more readily can the alloy be colored. The shades, and even the colors, can be altered by varying the density of the solution, its temperature and the length of time the object is immersed. They can also be altered by finishing the work in different ways. If a cotton buff is used one shade will be procured; a scratch brush will produce another, etc. Thus to color work the same shade as that of a former lot, all the data in connection with these operations must be preserved so that they can be repeated with exactness.

Many different kinds of salts are made into solutions for the coloring processes. When capable of producing the desired results it is always best to use the simple salts. It is often necessary to combine two or more salts in the solution to get the required color, but these deteriorate in strength much more rapidly than the simple salt solutions and hence the last piece immersed will have a lighter color than the first one. When adding salts to bring back the original strength of the bath, they should first be dissolved in a small amount of water to prevent their settling to the bottom where they might become covered with an insoluble mud that would prevent them from being dissolved. In making the solutions it should be remembered that a strong solution will produce the color quickly and a weak solution more slowly. When a uniform coating can be produced the strong solution is always the best owing to the time factor. The most effective and lasting results, however, are obtained with the weaker solutions, and hence they are used for high-grade work. While these solutions are often used cold, there are many cases where better results can be obtained when they are heated. Raising the bath to the boiling point will insure a complete solubility of the salt.

CLEANING WORK TO BE COLORED.

Cleaning the work is of the utmost importance before attempting to give it any kind of color. A greenish or brownish film forms on copper, brass, bronze, etc., when they stand, as they are attacked by the moisture in the air and the simultaneous presence of carbonic acid which gradually changes into carbonates. This film is a mixture of carbonate of copper and oxide. Often sulphur compounds are formed when the atmosphere is impregnated with the products of combustion arising from the coal gas burned in cities and towns. This is nearly always stronger in rooms than in the open. If these films are not removed before coloring they show up as stains and the work will be streaked or spotted. Touching the work with the bare hands after it is cleaned will also leave a slight film that will make the work spotted, and hence it should be strung on wires or handled in other ways that will prevent it from being touched with the hands.

Several acid dips can be made that will remove these films and leave the bright clean metal with its original smooth surface. Work that will stand heating can be heated to a dull red and then plunged into dilute sulphuric acid, after which it should be soaked in old aquafortis and then thoroughly rinsed. It should be soaked long enough to have a uniform metallic appearance, and the bath should be large enough in volume to prevent its heating up from the hot work. The best results are obtained with straw-colored aquafortis, as the white is too weak and the red too strong. In diluting the sulphuric acid it should always be poured into the water slowly, as heat is generated, and too rapid mixing generates so much heat that the containing vessel is liable to crack and the escaping liquid to cause burns. To pour water into sulphuric acid will cause an explosion that is almost sure to result in serious, if not fatal, burns from the flying liquid.

A good method of removing these films, without heat, is to soak the work in a pickle composed of spent aquafortis until a black scale is formed and then dip it for a few minutes into a solution composed of 64 parts water, 64 parts commercial sulphuric acid, 32 parts aquafortis and 1 part hydrochloric acid. After that the work should be thoroughly rinsed several times with distilled water. If the strong aquafortis is used for the pickle in which the work is soaked it will cause a too rapid corrosion of the copper during the time of the solution of the protoxide. Hence the spent aquafortis is better on account of its slower action and it also saves the cost of new. A dip that is useful for removing the sand, etc., that sticks to castings is composed of 1 part spent aquafortis, 2 parts water and 6 parts hydrochloric acid. A few minutes will suffice for small pieces, but large castings can remain in the bath for thirty minutes. They become coated with a black mud and when this is thoroughly washed off they should be bright.

If a further whitening of the work is desired a solution may be made by mixing 3 pounds nitric acid, 4 pounds sulphuric acid and 40 grains sodium chloride (table salt), combining this with 40 times its bulk of water and allowing it to cool before using. If a dead surface is desired the following mixture can be added to the bath: 2 pounds nitric acid, 1 pound sulphuric acid, 10 grains sodium chloride and 40 grains zinc sulphate. The degree of deadness is determined by the length of time the work is left in the bath. As with all other solutions, the work should be well rinsed after leaving the bath and then thoroughly dried. Another dead dipping bath can be made from one part of a concentrated solution of potassium bichromate and two parts of concentrated hydrochloric acid. Many other combinations of chemicals may also be made for cleaning or whitening the work or giving a dead finish after it has been colored, but those given above will suffice for the present.

BRIGHT CASTINGS.

The bright clean color sometimes seen on bronze castings has been thought by many to be the result of an acid dip. This has been produced, however, by plunging the castings into water while they are still red-hot. It is seldom that brass castings can be given this color as they usually contain too much lead. Likewise the bronze castings must be free from lead as well as iron, antimony or other impurities, and the water into which they are plunged must be clean, or a dirty, unpleasant color will be the result. The castings must also be as hot as possible when quenched. If too hot the metal will be brittle and hence the highness of the temperature is governed by the toughness that is desired in the casting, but if quenched after they have cooled too much the color will be dull. Copper ingots can be given a beautiful rose-red color by this method.

TO PRODUCE YELLOW TO ORANGE COLORS.

From a golden yellow to orange color can be given polished brass pieces by immersing them for the correct length of time in a solution composed of 5 parts caustic soda to 50 parts water, by weight, and 10 parts copper carbonate. When the desired shade is reached the work must be well washed with water and dried in sawdust. Golden yellow may be produced with the following: Dissolve 100 grains lead acetate in 1 pint water and add a solution of sodium hydrate until the precipitate which first forms is redissolved, and then add 300 grains red potassium ferricyanide. With the solution at ordinary temperatures the work will assume a golden yellow, but heating the solution darkens the color until at 125 degrees Fahr. it has changed to a brown. A pale copper color can be given brass by heating it over a charcoal fire, with no smoke, until it turns a blackish brown, then immersing in a solution of zinc chloride that is gently boiling, and finally washing thoroughly in water. Dark yellow can be obtained by immersing for five minutes in a saturated solution of common salt containing some free hydrochloric acid which has as much ammonium sulphide added as the solution will dissolve.

TO PRODUCE A RICH GOLD COLOR.

A rich gold color can be given brass by boiling it in a solution composed of 2 parts saltpeter, 1 part common salt, 1 part alum, 24 parts water, by weight, and 1 part hydrochloric acid. Another method is to apply to the work a mixture of 3 parts alum, 6 parts saltpeter, 3 parts sulphate of zinc and 3 parts common salt. The work is then heated over a hot plate until it becomes black and then washed with water, rubbed with vinegar and again washed and dried. Still another solution is made by dissolving 150 grains sodium thiosulphate in 300 grains water and adding 100 grains of an antimony chloride solution. After boiling for some time the red-colored precipitate must be filtered off, well washed with water and added to 4 pints of hot water. Then add a saturated solution of sodium hydrate and heat until the precipitate is dissolved. Immerse the brass articles in the latter solution until they have attained the correct shade. If left in too long they will be given a gray color.

TO PRODUCE WHITE COLORS OR COATINGS.

The white color or coating that is given to such brass articles as pins, hooks and eyes, buttons, etc., can be produced by dipping them in a solution that is made up as follows: Dissolve 2 ounces fine grain silver in nitric acid, then add 1 gallon distilled water and put into a strong solution of sodium chloride. The silver will precipitate in the form of chloride and this must be washed until all traces of acid are removed. Testing the last rinse water with litmus paper will show when the acid has disappeared. Then mix this chloride of silver with an equal amount of potassium bitartrate (cream of tartar) and add enough water to give it the consistency of cream. The work is then immersed in this and stirred until properly coated, after which it is rinsed in hot water and dried in sawdust.

SILVERING.

Another method of silvering that is applicable to such work as gage or clock dials, etc., consists of grinding together in a mortar 1 ounce very dry chloride of silver, 2 ounces cream of tartar and 3 ounces common salt. Then add enough water to make it of the desired consistency and rub it on the work with a soft cloth. This will give brass or bronze surfaces a dead white thin silver coating, but it will tarnish and wear if not given a coat of lacquer. The ordinary silver lacquers that can be applied cold are the best. Before adding the water, the mixture as it leaves the mortar can be kept a long time if put in very dark colored bottles, but if left where it will be attacked by light it will decompose.

ASSORTED COLORS.

Some very interesting results in coloring brass can be obtained by dissolving 200 grains sodium thiosulphate and 200 grains lead acetate in 1 pint water and heating it to from 190 to 195 deg. Fahr. Immersing the work in this for five seconds will make it pale gold; fifteen seconds, brown gold; twenty-five seconds, crimson; thirty seconds, purple; forty-five seconds, an iridescent bluish crimson green; sixty seconds, pale blue; sixty-five seconds, mottled purple; eighty seconds, nickel color; eighty-five seconds, mottled blue and pink; one hundred and ten seconds, mottled purple and yellow; two and one half minutes, pale purple; four minutes, mottled pink and yellow; five minutes, mottled pink and gray; ten minutes, mottled pink and light blue. Other combinations of colors can also be obtained, but some of these fade and change color unless protected by a coat of lacquer. By using one quarter ounce of sulphuric acid in place of the lead acetate a variety of colors can also be produced, but they will not be as good a quality as those made with the above solution. Nitrate of iron can be used with equally good results.

TO PRODUCE GRAY COLORS.

A solution of 1 ounce of arsenic chloride in 1 pint of water will produce a gray color on brass, but if the work is left in too long it will become black. The brass objects are left in the bath until they have assumed the correct shade and then are washed in clean warm water, dried in sawdust and finally in warm air. A dark gray color that can be made lighter by scratch brushing can be obtained by immersing the work in the following solution: 2 ounces white arsenic oxide, 4 ounces commercially pure (c. p.) hydrochloric acid, 1 ounce sulphuric acid and 24 ounces water. A steel gray can be produced with the following: 20 ounces arsenious oxide, 10 ounces powdered copper sulphate, 2 ounces ammonium chloride and 1 gallon common hydrochloric acid.

*Reproduced from *Machinery*.

After mixing, this should stand for one day. A 5 per cent solution of platinum chloride in 95 per cent water will also produce a dark gray color if i is painted on and the brass is warmed. Weaker solutions will make the color lighter. Copper can also be colored, but the platinum does not adhere as firmly to the surface as it does on brass. A coating of lacquer is required to make it permanent. By smearing the work with a mixture of 1 part copper sulphate and 1 part zinc chloride in 2 parts water and drying this mixture on the brass, with heat, a dark brownish color is obtained. If desirous of immersing the work a weaker solution could be used. The color is changed very little by exposure to light.

TO PRODUCE LILAC BLUE AND VIOLET COLORS.

The lilac shades can be produced on yellow brass by immersing the work in the following solution when heated to between 160 and 180 deg. Fahr. Thoroughly mix 1 ounce chloride, or butter of antimony in 2 quarts muriatic acid, and then add 1 gallon water.

To give brass a blue color dissolve 1 ounce antimony chloride in 20 ounces water, and add 3 ounces hydrochloric acid. Then warm the work and immerse it in this solution until the desired blue is obtained. After that, wash it in clean water and dry in sawdust. A permanent and beautiful blue-black can be obtained by using just enough water to dissolve 2 ounces copper sulphate and then adding enough ammonia to neutralize and make it slightly alkaline. The work must be heated before immersion. Copper nitrate, water and ammonia will also yield this rich blue-black, but if the brass is very highly heated after immersion it changes to a dull steely black. On copper or work that is copper-plated this latter produces a crimson color.

A beautiful violet color can be produced on polished brass with a mixture of two solutions. First, 4 ounces sodium hyposulphite is dissolved in 1 quart water, then 1 ounce sugar of lead is dissolved in another quart of water and the two are well stirred together. By heating this to 175 deg. Fahr. and immersing the work the correct length of time, it takes on the violet color. The work first turns a golden yellow and this gradually turns to violet. If left a longer time the violet will turn to blue and then to green. Thus this same preparation can be used for all of these colors by correctly limiting the time that the work is immersed.

TO PRODUCE GREEN COLORS.

When left to the natural action of the atmosphere, or ageing, most of the brasses and bronzes first turn green, and very decidedly so if near the ocean where the moisture from the salt water attacks the metal. This green color gradually darkens and then turns brown and finally black. Some of the shades it assumes are very beautiful and hence they have been produced by chemical means, as nature is too slow in its action. So many different chemical combinations are used for this purpose that it would require a book to enumerate them all and hence only a few can be mentioned. Some of the green colors can be produced by the solutions given above, but the antique, or rust, greens require different mixtures.

One solution that will produce the verde antique, or rust green, is composed of 3 ounces crystallized chloride of iron, 1 pound ammonium chloride, 8 ounces verdigris, 10 ounces common salt, 4 ounces potassium bitartrate and 1 gallon water. If the objects to be colored are large, this can be put on with a brush and several applications may be required to give the desired depth of color. Small work should be immersed and the length of time it is immersed will govern the lightness or darkness of the color. After immersion, stippling the surface with a soft brush, dampened with the solution, will give it the variegated appearance of the naturally aged brass or bronze. Another solution that will give practically the same results is composed of 2 ounces ammonium chloride, 2 ounces common salt, 4 ounces aqua-ammonia and 1 gallon water. The work may have to be immersed or painted several times to give it the desired coating, and after washing and drying it should be lacquered or waxed. The Flemish finish can be given brass with a solution composed of ¼ ounce sulphuret of potassium, 1 to 2 ounces white arsenic, 1 quart muriatic acid and 10 gallons of water. The arsenic should be dissolved in a part of the acid by heating and then mixed with the balance of the acid and water. Two ounces sulphuret of potassium in a gallon of water may also be used if it is heated to 160 deg. Fahr. One ounce sulphuric or muriatic acid in a gallon of water darkens the color produced by this last mixture.

TO PRODUCE BROWN COLORS.

Many different shades of brown can be produced and many different chemicals are used to form solutions or pastes for this purpose. In these liver of sulphur, either potassium sulphide or sodium sulphide, is one of the most commonly used chemicals. One-fourth ounce liver of sulphur in 1 gallon water will give bronze a brown color when used cold, but if heated it is more effective. The depth of the color is governed by the length of time that the work is immersed. If left in too long, however, it becomes black and if too much liver of sulphur is used the color will be black. Copper is turned black even with the weak solutions. To set the color it should afterward be immersed in water containing a small amount of sulphuric or nitric acid. Brass is not attacked by this solution, but if caustic potash is added it causes the liver of sulphur to color the brass. Then 2 ounces liver of sulphur should be added to 1 gallon water and from 2 to 8 ounces caustic potash, according to the shade of brown that is desired; the more potash the darker will be the color. A solution composed of ½ ounce potassium sulphide in 1 gallon of water will produce a gray or greenish color on brass when cold, but when heated to 100 deg. Fahr. it produces a light brown; at 120 degrees, a reddish brown; at 140 degrees, a dark brown; and at 180 degrees, a black color.

The barbedienne bronze, or brown, color can be produced on cast brass or bronze by immersing in a solution made by dissolving 2 ounces golden sulphuret of antimony and 8 ounces caustic soda in 1 gallon water. The work must be properly cleaned beforehand and afterward scratch-brushed wet, with a little pumice stone applied when brushing. It must then be well washed and dried in sawdust. A second immersion in a solution of one half the above strength will have a toning effect, and the work must again be washed and dried. The high light can be made to show relief by rubbing the object with pumice stone paste on a soft rag. A dead effect can be produced by immersing in a hot sulphuret of antimony solution for ten or fifteen seconds, then rewashing and immersing in hot water for a few seconds and drying in sawdust. The work should be lacquered to preserve the tones and waxed when the lacquer has become dry and hard. This brown color can be darkened by a five seconds immersion in a cold solution of 8 ounces sulphate of copper in 1 gallon water. Some other processes use two solutions, the first of which is heated and the second used cold, after which the work is rinsed in boiling water.

TO PRODUCE BLACK.

There are as many different processes and solutions for blackening brass as there are for browning, and consequently only a few can be given. Trioxide of arsenic, white arsenic or arsenious acid are different names for the chemical that is most commonly used. Its use can be traced back to the fifth century and it is the cheapest chemical for producing black on brass, copper, nickel, German silver, etc. It has a tendency to fade and a much greater tendency if not properly applied, but a coat of lacquer will preserve it a long time. A good black can be produced by immersing work in a solution composed of 2 ounces white arsenic and 5 ounces cyanide of potassium in 1 gallon water. This should be boiled on a gas stove in an enamel or agate vessel and used hot. Another cheap solution is composed of 8 ounces sugar of lead, 8 ounces hyposulphite of soda and 1 gallon water. This must also be used hot and the work afterward lacquered to prevent fading. When immersed the brass first turns yellow, then blue and then black, the latter being a deposit of sulphide of lead.

The ammonia-copper carbonate solution much used for medals, ornaments, etc., is made by taking the desired quantity of the strongest ammonia water and mixing it with an equal amount of distilled water, and dissolving carbonate of copper in it until it is thoroughly saturated and a little remains undissolved. This is placed in a stone crock and surrounded with water and then heated to from 150 to 170 deg. Fahr. before the work is immersed. After immersing for a few seconds the brass will turn black and it is then removed and first rinsed in cold water and dried and then given a coat of dead, black lacquer.

A black that will withstand the wear of such articles as desk telephones can be given to brass with a solution that is made as follows: Mix 1 ounce nitrate of copper with 1 ounce water. Then mix 1 ounce nitrate of silver with 1 ounce water. Then combine 1 part of the nitrate of silver solution with 2 parts of the nitrate of copper solution and 3 parts water. Heat the brass, bronze or copper article to 250 deg. Fahr., and give it two coats of this solution with set-in-rubber brushes. When the fluffy smut is brushed off with a stiff bristle brush, the work will be found to have a pleasing brownish black color that is tenacious. If it is desired to change this to a dead black the article can be immersed for 5 minutes in a cold solution made from 2 ounces liver of sulphur in 1 gallon water. It is then removed and heated until uniformly dead black and again brushed. It can then be given a coat of flat lacquer or waxed.

OXIDIZING.

Solutions that produce the green, brown or black colors are usually used when it is desired to oxidize copper, brass or bronze. A dark slate green can be produced with a solution composed of 8 ounces double nickel salts, 8 ounces sodium hyposulphite and 1 gallon water. The color is almost instantly produced when the temperature of the solution is above 150 deg. Fahr., but below the boiling point, and the articles immersed. After removing and rinsing in water the relief is easily produced with pumice stone or other abrasives. This green color harmonizes well with the metal color.

The browns and blacks are coated on the metal in the same manner as described above under these headings; the solutions that are used hot give the best results, as the coating is more tenacious and better withstands the buffing that is necessary when oxidizing the work. Many beautiful effects are produced by these combinations of colors, and while it is not difficult to relieve the rough surfaces of cast, stamped or pressed articles it requires considerable skill to relieve turned or polished surfaces.

MOTTLING.

After properly buffing and cleaning the work, a handsome mottled effect can be produced by first immersing it in a boiling solution composed of 8 ounces sulphate of copper, 2 ounces sal ammoniac and 1 gallon water. This produces a light taffy color that soon changes to an olive green. The work should be removed when the taffy color appears and dipped in a second solution composed of 4 ounces sal-soda in 1 gallon water and that has the surface covered with a small amount of lard, oil or gasoline. After that the work is again immersed in the first solution until the olive-green color is produced. The oil spreads over the surface and prevents the uniform action of the first solution, and hence the taffy and olive-green colors are mottled together wth a pleasing effect. The same process might be used with different chemical solutions to mottle work with other combinations of colors.

COLORING ALUMINIUM.

Aluminium is the most difficult of metals to color. Heretofore aluminium parts have only been colored by coating them with lacquers of different colors, but a process has recently been patented by Salamon Axelrod in Germany that produces different metallic colors. Either a neutral or alkaline cobaltous nitrate is made into a water solution into which the articles are dipped, or it may be painted on pieces too large to dip. After that the work is heated and the degree of heat determines the color. A low temperature produces a steel gray color that changes to brown with a higher heat and to a durable and permanent dead black when the temperature is still higher. Zinc, tin and other white metals may also be colored with similar cobalt salt solutions.

The gun-metal finish can be given aluminium by immersing it for from six to ten seconds in a cold solution of 12 parts hydrochloric acid, 1 part chloride of antimony and 87 parts distilled water. After that, thoroughly wash it in running water for several minutes, dry with heat and lightly buff with a high-speed wheel. The color penetrates the metal and its depth is governed by the length of time it is immersed. If immersed longer than ten seconds the solution should be weakened, as hydrochloric acid eats the metal.

Nearly any color can be plated on any of the metals or alloys by electro deposition, but this is an art or trade that requires experienced platers. Electrochroma is the name given a new plating process that promises to revolutionize the older methods of plating on colors. It produces any desired shade of green, blue, red, violet or yellow and black and white by immersion in the electrolyte for from one half minute to two minutes. The work is made the cathode. One of its special features is the coloring of leaded glass. The lead can be given any desired color, while the glass is not affected but is left clean and with a clear luster. Heretofore the lead has been painted by hand, which was a long, tedious job, often consuming a day or more for one piece. It is also easy to match colors with this plating process and they are permanent enough not to require lacquering or waxing. The plating processes, however, are separate and distinct from those given above, as these do not require an electric current nor the high degree of knowledge and skill that goes with the plater's profession.

Counting Electrons and Molecules

Dr. H. Geiger, of the Reichsanstalt, who four years ago, in conjunction with Prof. Rutherford, devised a method of counting the number of α particles emitted by a radio-active body, has now, according to a communication from the Reichsanstalt, succeeded in perfecting a very simple method which allows both the α and β particles to be counted. The α or β rays are allowed to enter a short metal cylinder 2 centimeter diameter, by a small hole in the base. Through an ebonite block which closes the other end of the cylinder a sharp pointed rod projects into the cylinder to within 0.8 centimeter of the base. The cylinder is raised to about 1,200 volts, and the pointed rod is connected to a string electrometer provided with a high-resistance leak. The entry of either an α or a β particle into the cylinder causes a spark to pass between point and cylinder, and the electrometer of 10 centimeters capacity acquires a charge corresponding to 10 to 20 volts. The throws of the electrometer are recorded photographically, and the results obtained are in agreement with those calculated from ionization observations in the case of the polonium preparation used in the observations.—*Nature.*

Staling of Bread Explained in the Light of Physical Chemistry*

Fallacy of the Popular Idea That the Staling of Bread is Due to Drying

By Dr. Richard Lorenz

A GERMAN chemist, Dr. J. F. Katz, has recently carried out some important investigations into the cause of the staling of bread. It is quite generally supposed that this effect is due to the drying of the bread, that is to say, to loss of moisture on standing exposed to the air.

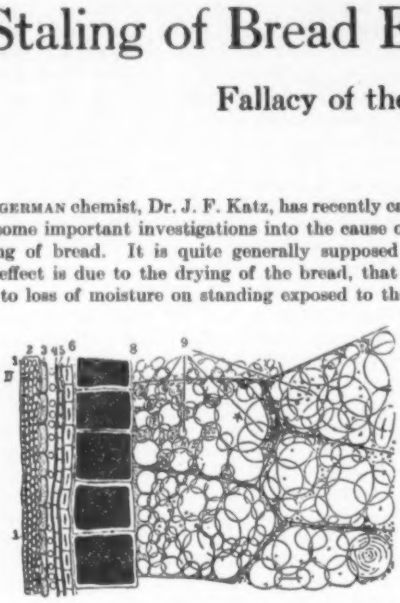


Fig. 1.—Transverse section through a grain

1. Epidermis. 2. Longitudinal cells. 3. Transverse cells. 4. Tubular cells. 5, 6. Pigmented layer. 8. Gluten cells. 9. Starch granules. (After Hars.)

However, actual weighings have disclosed the somewhat surprising fact that this explanation is quite inadequate, that in fact the loss of moisture is at most only very slight, and quite insufficient to account for the very marked changes in the properties of bread, on standing. Moreover, it is well known that at least a temporary restitution of the freshness of bread can be secured by placing it for a time in an oven of suitable temperature, a proceedure which could not be explained, if the staleness of bread were due to the loss of moisture, for on being placed in the oven, the bread would more likely lose than gain moisture.

Before we proceed to a consideration of the researches of Dr. Katz, it will be well to briefly recapitulate some of the main features relating to the raw materials employed in making bread and to the processes involved in this operation.

For the preparation of bread, two cereals are used exclusively in our climates, namely wheat and rye. If we examine a section of a wheat or rye grain under the micropscope, we observe first of all an outer woody layer, the epidermis (see Fig. 1). Beneath this is a row of longitudinal cells and next to these, a number of transverse cells, among which are interspersed tubular cells. Below these is a layer of comparatively large, square cells, containing a granular albuminous material, the so-called gluten. The layers thus enumerated form an outer covering for the main contents of the seed, the starch cells. In these are seen a vast number of roughly round or oblong starch grains, embedded in a matrix of gluten. When the grain is ground between the millstones, the external woody shell and the gluten cells attached to it, are broken off to form the bran. This of course represents a serious loss of materials possessing a high nutritive value, for the only albuminous material retained in the flour is the gluten of the starch cells. If ordinary flour is looked at under the microscope, the first striking feature observed is the large number of starch granules derived from the core of the grain. In Fig. 3, there are seen in addition to a number of starch granular cells, also the spaces left by granules which have dropped out. The finer the flour is ground, the greater is the proportion of loose starch granules, the more gluten remains adhering to the millstones, and passes off with the bran. The presence of gluten has a very marked influence upon the color of the flour. The coarser the flour, the darker yellow or brown it appears. In the so-called whole wheat flours, employed in baking dark breads, the bran is intentionally put back into the flour after it has been ground. Breads made in this way are very nutritious, on account of the presence of much gluten, but on the other hand the woody portions of the shell make it rather indigestible.

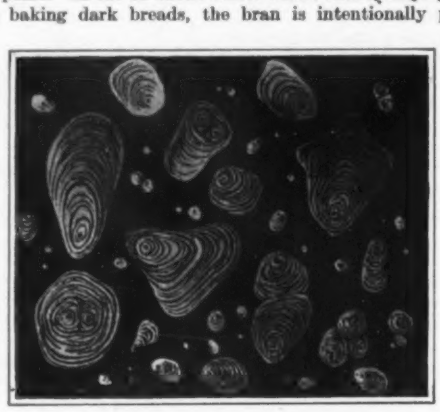


Fig. 2.—Granules of potato starch.

The baking of bread depends essentially upon the properties of the starch and gluten, the principal constituents of the flour. As regards, first of all, the starch granules, these are organic compounds of high complexity related to cellulose and the sugars, together with which they constitute the group of so-called polysaccharides. These are a special group of carbo-hydrates, which contain in addition to carbon, the elements of hydrogen and oxygen in the proportion which they combine to form water. The molecular formula of starch is commonly regarded as $(C_6H_{10}O_5)n$ where n is an unknown, but rather large number. So much for the chemical composition of starch. As regards its grosser structure, starch derived from wheat, rye, the potato, etc. is always formed of granules displaying a distinct concentric arrangement (see Fig. 2), and exhibiting a characteristic Maltese cross effect under the polarizer, (see Fig. 4).

The property of the starch grains which is of special importance for our present considerations, is their faculty of swelling up in water, and the fact that when raised to a certain temperature with water they form a kind of paste or jelly. If starch flour is heated with a little water, first of 50 deg. Cent., and is inspected under a microscope, there is first noticed a swelling of the individual grains. This continues, and at a temperature of from 50 to 60 degrees, most of the grains burst open and their contents are discharged, (see Figs. 5 and 6). At a temperature of 60 to 70 degrees the grains undergo a complete change, and form a gelatinous mass, (see Fig. 7) which is dissolved on the addition of a further quantity of water, forming a colloidal solution. At temperatures between 70 and 80 degrees, the gluten also undergoes a change and coagulates, as is typical of albuminous substances generally.

Both the changes herein described, the formation of a gelatinous paste and the coagulation of gluten take place, of course, also when the flour is made into dough with water and is gradually heated to 200 deg. Cent. in the oven.

THE STALING OF BREAD.

The product so obtained (unleavened bread or matze) is therefore mainly coagulated gluten through which is distributed gelatinized starch. Ordinary bread differs from this product in being very porous and light. As the reader knows it is easy to prepare by adding yeast or similar material to the dough. The yeast causes a fermentation to take place in the dough, according to the following equation:

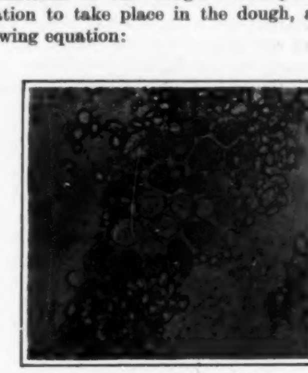


Fig. 3.—Wheat flour. Cells containing starch granules and gluten.

$$C_6H_{10}O_5 + H_2O = 2\,C_2H_5OH + 2\,CO_2$$

Sugar (from the starch) + water = 2 alcohol + 2 carbon dioxide.

The carbon dioxide which is liberated in the fermentation causes the bread to "rise" as it becomes blown up with numerous small bubbles of gas which constitute the holes in the finished bread. In the course of the baking operation, all the yeast and other organisms are killed off while the alcohol and the excess of water are driven off. The carbon dioxide of course also escapes, though before doing so, it has rendered the bread porous. So long as the gluten in the dough has not coagulated, the rising process continues. When the temperature, however, reaches about 70 to 80 deg. Cent., the gluten coagulates to a rigid skeleton in which are embedded the starch grains.

Freshly-made bread has a soft and elastic consistency. To the present day very little is known with regard to the cause of that important change which bread undergoes on standing, the so-called staling of bread. If fresh bread is allowed to stand in the air, it soon loses its

Day.	Hour.	Temperature in Deg. Cent.		Weight of Bread in Kilogram's.
		Bread	Room	
12 June	9 a. m.	97.0	19.0	3.760
	10 "	81.0	19.1	
	11 "	68.0	19.0	
	12 noon	58.1	19.1	
	1 p. m.	50.2	19.0	3.735
	2 "	44.0	19.0	
	3 "	38.6	18.9	
	4 "	34.7	19.0	
	5 "	31.6	18.7	
	6 "	28.9	18.6	
	8 "	25.0	18.4	
	10 "	23.0	18.3	
13 June	7 a. m.	18.8	18.1	3.730
	9 "	18.3	18.1	
	10 "	18.1	18.1	
	11 "	18.0	18.0	
	12 noon	18.0	17.9	
	2 p. m.	18.0	18.0	
	7 "	17.8	17.7	
14 June	9 a. m.	17.0	17.4	3.727
15 June	9 "	16.1	16.5	3.712
16 June	9 "	15.8	16.3	3.700
17 June	9 "	15.8	16.3	3.696
18 June	9 ".	15.8	16.3	3.690

*Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from *Die Umschau*.

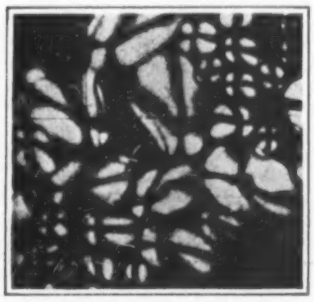


Fig. 4.—Potato starch as seen under crossed nicols.

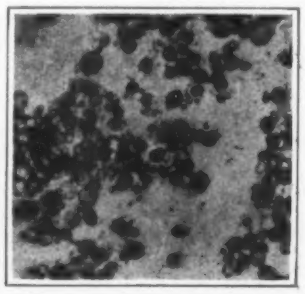


Fig. 5.—Rye-flour in original (unswelled) condition.

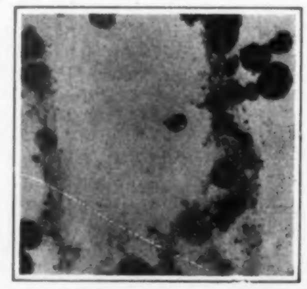


Fig. 6.—Rye-flour swelled with water at 50 deg. Cent.

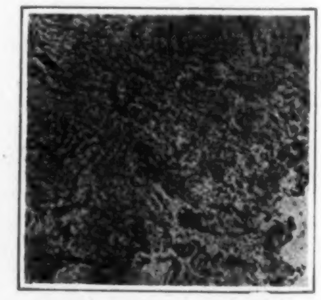


Fig. 7.—Rye-flour after gelatinization by water and heat.

elasticity and becomes hard and brittle. Old bread can be powdered without difficulty under the mortar, which of course is quite impossible with fresh bread. The layman is inclined to ascribe the staling of bread to the loss of moisture on exposure to the air. But as long ago as 1853 the celebrated French agricultural chemist, Boussingault drew attention to the fact that this supposition is not in accordance with facts. He showed that very old bread contained almost exactly as much water as fresh bread. The appended table shows some of the results obtained by Boussingault.

It appears from this table that bread just taken from the oven loses about one per cent of its weight on cooling to a low temperature, but that after this, further loss of weight by evaporation of water gradually diminishes, and that finally after a week (when the bread of course has become completely stale) only about two per cent of the total moisture has been lost. When we consider that bread commonly consumed contains 35 to 45 per cent of water, it will be evident that the 2 per cent loss which has occurred in the process of staling can hardly be made responsible for the extensive changes which accompany that process.

Boussingault and others therefore had to admit that the process was not accounted for by loss of moisture but that it must be due to some unknown change in chemical or physical constitution. It was left to modern physical chemistry to shed light on this remarkable process. The facts which gave a clue to the nature of the staling process is the well-known observation that stale bread can be temporarily renovated by heating it in the oven. If stale bread is heated to about 70 to 80 deg. Cent. for a time in a closed space (closed in order to prevent the escape of moisture) and then allowed to cool, it is very nearly restored to its original condition, and in fact, differs from fresh bread only in that it stales somewhat more rapidly. This phenomenon has been explained by J. N. Katz, who has shown that the conversion of stale bread into fresh and *vice versa* is a case of a so-called allotropic change. Numerous cases are known in which one body can exist in two or more forms, each of which has a certain definite temperature interval, within which it is stable, while, when this interval is exceeded, the substance passes over into one of the other forms. The change does not necessarily occur immediately, but there may be a certain time during which the substance is temporarily in an unstable form at a temperature at which one of the other forms of which it is capable is the truly stable one. Thus it is known that mercury iodide displays a brilliant red color at temperatures up to 127 deg. Cent., but at this temperature it acquires a lemon yellow color. If now the mercuric iodide is slowly and carefully cooled, it does not turn red again exactly at 127 degrees, but can be cooled down as far as 100 degrees, below its normal transition point. It is however, unstable in this form and goes over into the red variety under the influence of such a slight stimulus as mere rubbing.

According to Katz the case of bread is quite similar. While we cannot at the present time indicate exactly the transition point for the change from fresh to stale bread, we do know that stale bread represents for ordinary temperatures the stable form. This form is stable between temperatures ranging from about— 80 degrees to + 60 degrees Cent. The interesting point from a standpoint of physical chemistry is the fact that fresh bread represents a metastable form, similar to the red mercuric iodine at ordinary temperatures. The change from fresh bread into stale bread proceeds most readily at centigrade, that is to say at the freezing point of water. On the other hand, bread which has been kept for a long time in liquid air is found quite fresh after thawing, just like bread which has been heated to 80 deg. Cent. But if stale bread is renovated by heating, it is found that such bread falls back into the stale condition more rapidly than before. A similar state of affairs has been observed in the case of a number of other metastable bodies also, called fatique.

Experiments on "Suction" Between Passing Vessels*

An Investigation Provoked by the "Olympic"-"Hawke" Collision

By Professor A. H. Gibson, D.Sc., and J. Hannay Thompson, M.Sc.

1. The experiments to be described in this paper have been carried out with a view of obtaining some information as to the magnitude and range of action of the forces involved in the case of "suction" or interaction between passing vessels. Up to the present time in such experiments as have been performed models of comparatively small size have been used, and while these have given extremely valuable results, some doubt has been expressed as to the extent to which their results are susceptible of extension to the case of vessels of large size.

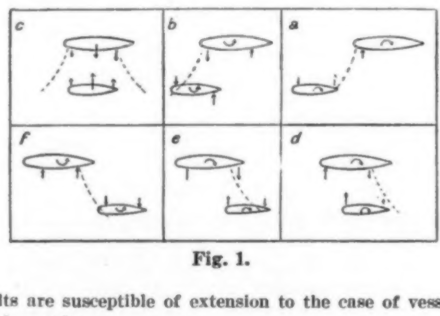


Fig. 1.

In the present series of experiments two screw propelled vessels were used. One of these, the steam yacht Princess Louise, is 88.5 feet in length, 13 feet beam, 5.66 feet mean draught, displacing approximately 96 tons. The second is a motor-driven launch, 29.33 feet long, 6.75 feet beam, 1.37 feet mean draught, displacing approximately 2.6 tons. Each is driven by a single screw. The experiments were divided into two distinct sets. In the first the vessels were maneuvered until on sensibly parallel courses, heading for the same distant object, their lateral distances apart and speed being varied in different experiments. The courses having been satisfactorily fixed, with the helm of the motor boat amidships, this helm was lashed, the helm of the Princess Louise being afterwards manipulated so as to keep her on her original course. Two plane tables with alidades were mounted on the deck of the Princess Louise, distant 67 feet 8 inches center to center, and the relative position of the motor boat was fixed at intervals of fifteen seconds during each run by means of simultaneous sights taken from these. Both vessels were calibrated on the measured mile before the experiments, and speed revolution curves were obtained from which, by counting the revolutions, the speed of each vessel could be ascertained or regulated. These data enabled the relative positions and paths of the two vessels to be plotted with a close degree of accuracy, and the diagrams illustrating the paper have been obtained in this way. With a view of measuring the forces and moments involved a series of eight pressure-boxes were fixed to the hull of the motor boat at about 12 inches below the waterline. These are circular, have a diameter of 1½ inches, and a maximum thickness of ⅜ inch, and communicate with the sea through four 1/16-inch holes on a linear circle. They are in pairs at similar positions on the port and starboard sides, and distant 4 feet, 10 feet, 16 feet and 22 feet from the bows. Each corresponding pair was attached by means of rubber tube connections to the branches of one of a series of inverted U tubes carried on deck, and by exhaustion of the air from the top of the tubes a column of fluid from each pressure-box was brought on to a graduated scale, from which the differences of pressures at corresponding

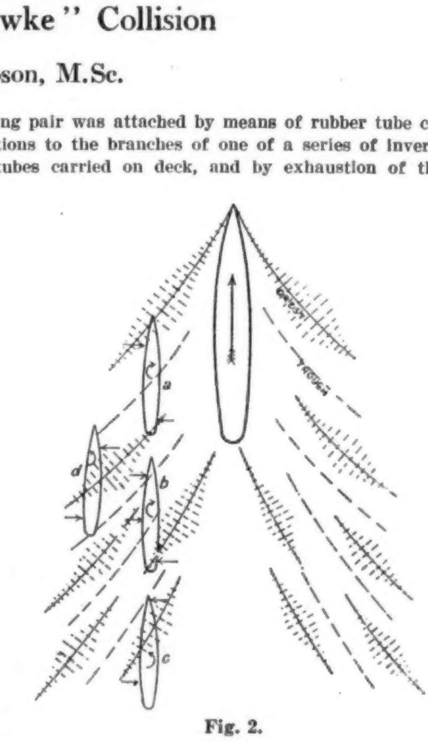


Fig. 2.

* Report presented to the Institution of Naval Architects and published in the *Engineer*.

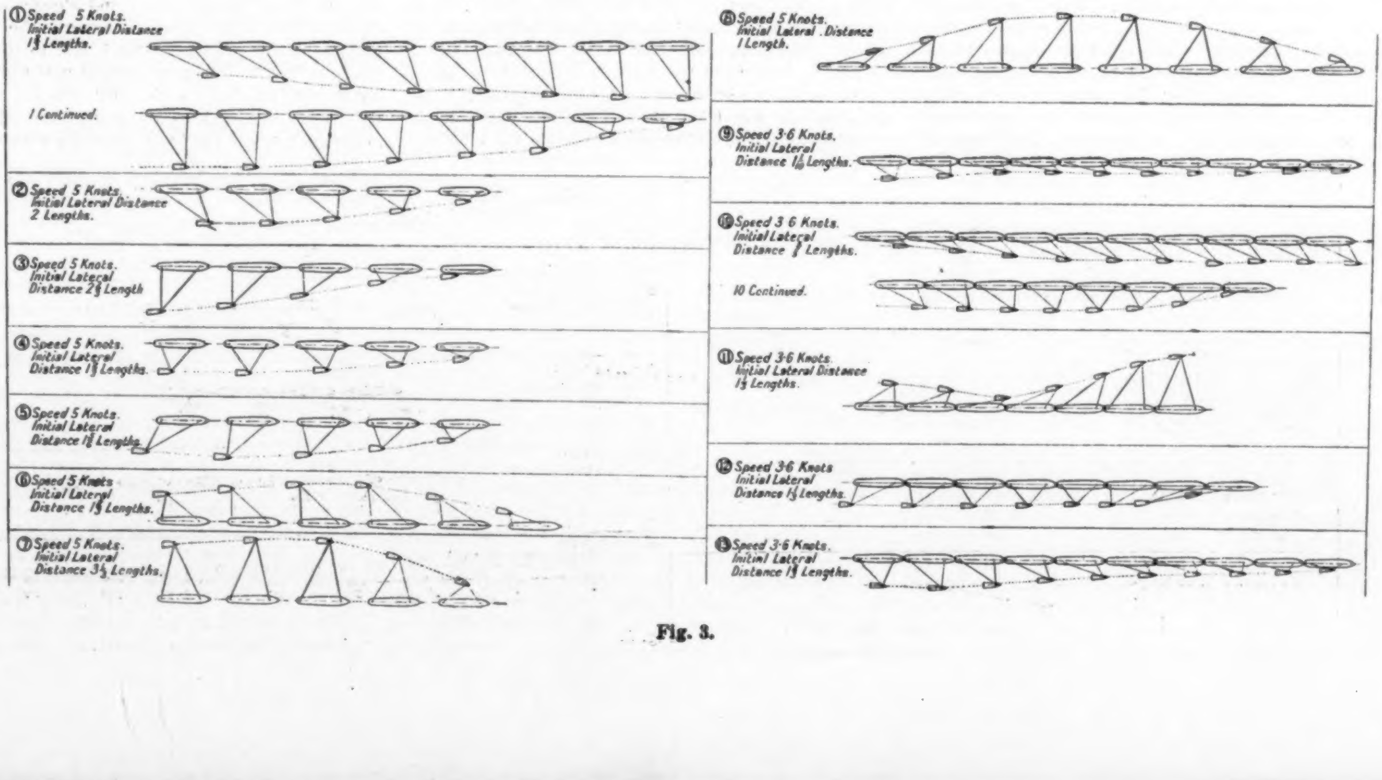


Fig. 3.

points were determined. Each pair was calibrated at different speeds so as to give the zero reading with the boat traveling on a straight course and remote from any disturbing influence.

Readings of the gages were taken each fifteen seconds in a number of the experiments, and from these the paper. Owing to the risks involved in the collisions the speed of the vessels was restricted to a maximum of about 5.75 knots, which, in the case of the Princess Louise, corresponds to 18 knots in a vessel of the dimensions of the Olympic (882 feet long). The minimum speed was about 3.5 knots. Owing to the local condi- of flow increase the pressure diminishes, to become a minimum abeam of the body, while as, due to convergence at the stern, the velocities diminish, the pressure again increases. The body thus carries along with it a region of depression abeam and fan-shaped regions of excess pressure and super-elevation ahead of its

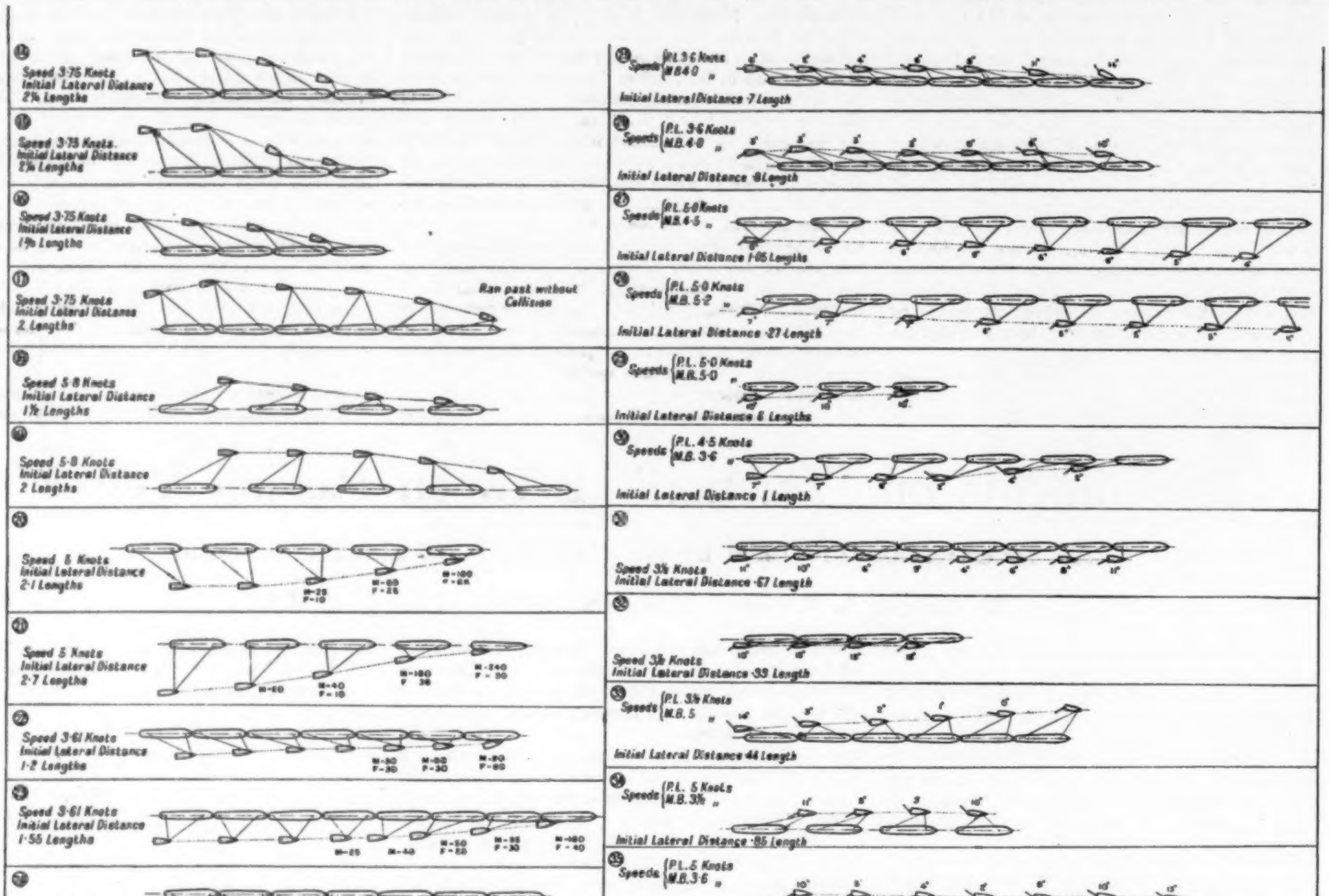


Fig. 4.

the turning moments and lateral forces acting on the hull of the boat have been computed. The second series of experiments was carried out with a view of measuring the helm angle required to maintain the course of the smaller, when in the vicinity of the larger vessel. In these experiments the relative positions of the two boats were obtained as before, the helm being adjusted as required to keep the head of the vessel on its original course. The helm angle was measured by means of a pointer fixed to the tiller, and working over a graduated sector, and was observed at intervals of 15 seconds. The rudder originally fitted to the motor boat was proportionately about three times as large as is fitted to the average sea-going steamship. This was replaced for the purpose of the experiments by a rudder of 144 square inches area, for which one of 75 square inches area was afterwards substituted, the latter representing approximately to scale the rudder fitted to the average large steamship. The results of control experiments using each rudder in turn are given at a later stage of tions it was found impracticable to carry out the experiments in shallow water of even approximately constant depth, and, except in two experiments (Nos. 41 and 42, Fig. 5), where the water was about 12 feet deep, the depth actually ranged from 20 feet to 30 feet. Since this is from twelve to twenty times the mean draught of the smaller vessel, these are essentially deep-water experiments, and, as is indicated both by theory and experiment, the forces involved are in general less than would be experienced in shallow water.

2. General Theory of Interaction.

When a ship-shaped body is towed through still water both theory and experiment show that a general circulatory motion is set up in the surrounding fluid. Those particles ahead of the bows are first affected, being forced forwards and outwards into a fan-shaped region extending ahead from the bows, in which the pressure and elevation are greater than normal. From this region a general flow takes place, backwards and inwards to fill the space vacated by the stern. As the velocities bows and in the rear of its stern. The pressures and velocities of flow diminish rapidly as the distance from the vessel increases the pressures varying as the square of the corresponding velocities. They are greatest in a narrow channel where the area available for backward flow is restricted, while theory indicates that they are of necessity greater in shallow water in which flow takes place in layers approximately parallel to the surface, than in deep water where inflow and outflow may take place freely in vertical as well as in horizontal directions. When a vessel is propelled by its own screw the distribution of pressure is somewhat modified. The screw propeller, drawing a large volume of water from regions ahead and abreast of itself and throwing this astern, tends to increase the velocities of flow, to reduce pressures ahead, and to increase those astern of itself. When two ship-shaped bodies are moving in close proximity each affects the lines of flow and the distribution of pressure around the other. Those pressures between the hulls suffer the greatest modifica-

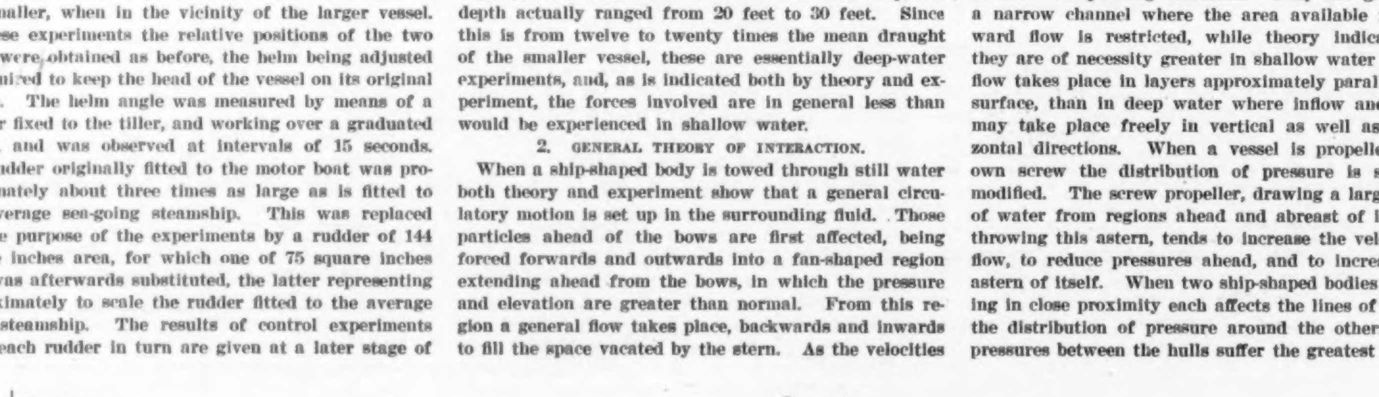


Fig. 5.

tion, and it is this modification in the distribution of pressure over the two sides of each of the vessels which gives rise to interaction between the two. If one vessel is overtaking a second one on a parallel path the effect on the overtaking boat of the system of currents accompanying the leader is broadly as follows: As the faster vessel draws up astern it first comes within the influence of the outflowing current astern of the leader, and as the strength of these is greater at its bows it experiences a tendency to sheer off from the leader.—Fig. 1*a*.

Creeping farther ahead, its bows come within the influence of the inflowing currents while its stern is still being repelled, and it consequently tends to sheer in—Fig. 1*b*. This tendency generally becomes a maximum when the bow of the follower is a little abaft the beam of the leader, the exact relative position depending on the relative sizes and distance apart of the two vessels. If the follower passes this point in safety the tendency to inward sheer gradually diminishes until, when a little abaft the beam of the leader, it disappears and is replaced by a strong tendency to bodily inward drift—Fig. 1*c*. A farther advance reduces the inward force on the bows and increases that on the stern, with a consequent tendency to outward sheer—Fig. 1*d*—which is increased when, as in Fig. 1*e*, its bows come within the influence of the outflowing currents from the bows of the leader. Finally, as the follower draws ahead and becomes the leader, both bow and stern come within the influence of these currents, and, those at the stern being greatest, the stern is repelled more strongly than the bows, and the vessel tends to sheer inwards—Fig. 1*f*. The influence of the currents produced by the follower will, of course, be felt by the leader, and will tend to produce erratic movement on its part. The relative magnitudes of the various forces, and the exact point at which they change sign, varies with the relative sizes of the vessels and with their distance apart, but their general nature as regards direction and effect on both vessels with ships of the relative sizes and at the relative distances shown is indicated in the diagrams of Fig. 1. The arrows applied to the bow and stern of the vessels in these diagrams show the directions of the resultant forces at each point, and the curved arrows on each vessel indicate the direction of sheer under these forces. The curved dotted lines in the diagrams mark the boundaries between the regions of positive and negative pressure accompanying the leading vessel. If, instead of being parallel, the overtaking vessel is inclined to the leader in the position *b*—Fig. 1—the inflowing currents act more directly on its bows, and at a given distance their effect will be consequently increased.

Modifying effect of bow and stern waves.—Any ship-shaped body in motion is accompanied by a train of waves diverging from the bow and stern, and often, in addition, from some one or more points amidships, as indicated in Fig. 2, in which the full lines represent the crests and the dotted lines the troughs of the waves. The exact type of wave formation and the relative positions of crests and hollows with any given ship depend on its speed, and the modifying effect on a second vessel of the distribution of pressure set up by these, depends largely on the relative lengths and positions of the two vessels. Under the circumstances indicated in Fig. 2, however, the effect will be broadly as follows: If the follower be at *a* the height of water at a given point on its port side near the bows is greater than at the corresponding point on the starboard side, with a consequent resultant pressure to starboard. Near the stern, however, the resultant pressure at corresponding points is to port, and as a result of these forces the vessel will tend to swerve in towards the leader. The same holds true if the vessel be in the position *b*, while if in position *c* or *d* the reverse is the case. With a longer vessel in the same position relative to the leader, these actions would be modified and might indeed be entirely reversed, while at different speeds with a different wave formation, the effects would also be different. In any particular case, however, these waves tend to modify the effect of the circulatory currents, increasing this in some positions and reducing it in others.

The difference due to this cause in the lateral forces over corresponding vertical elements of the hull is, however, not nearly so great as would be produced by the same statical differences of level, since the pressure at a given depth below the crest of a wave is less than at the same depth below the trough. At a given point in water through which a train of waves is progressing the pressure becomes more nearly constant and equal to the pressure at the same point in the water at rest, as the depth of the point increases. With a vessel of draught so great that the vertical orbital motion of the particles at the level of its keel is negligible, the resultant lateral force over any vertical element of the hull would indeed be unaffected by the presence of the wave.

The deeper the water the greater is the vertical motion at a given depth accompanying a given wave formation, and the greater the resultant effect on a vessel of given draught. From this it appears that the wave effect is greatest in deep water, where the effect of interaction is otherwise least, and *vice versa*. That the result may be very appreciable with suitable relative lengths of ship and wave is evident when it is realized that a mean effective elevation of 1 inch on the one side from bow to midships, and a mean elevation of the same amount on the other side from midships to stern of a vessel 360 feet long drawing 20 feet of water, involves a sheering moment of the order of 1500 foot-tons.

3. EXPERIMENTAL RESULTS.

Diagrams 1 to 19—Figs. 3 and 4—show graphically the results of typical experiments in which the helm of the motor boat was lashed amidships. In the experiments shown in Diagrams 1 to 8 the speed of the Princess Louise was 5.1 knots; in those of Diagrams 9 to 13 it was 3.61 knots; while in those of Diagrams 14 to 19 it varied from 3.6 to 5.8 knots. The experiment shown on Diagram 1 shows the repulsion when the smaller boat is ahead of the larger, gradually changing into an attraction as the latter boat draws abreast, and finally producing collision from a lateral distance of 3.4 lengths of the smaller boat. Experiments 2 to 7 show the same attraction occurring at different relative longitudinal positions of the vessels, with lateral distances ranging from 1.7 to 3.5 lengths of the smaller boat. Initial repulsion is well marked in No. 8, in which the steam yacht Princess Louise is the faster vessel. Attraction, however, becomes apparent at a distance of three lengths when the vessels are approximately abeam, and is followed by collision in one minute. In the experiments 9 to 13 the speed of the Princess Louise was 3.61 knots. Experiment 9 is interesting as showing the vessels in relative positions in which, in spite of their close proximity, the resultant moment is approximately zero. Experiment 10, in which the Princess Louise is somewhat faster than the motor boat, shows the repulsion when the smaller boat is slightly ahead, changing to attraction as the larger boat draws abreast, and terminating in collision from a distance of one and a-half lengths. The repulsion is also well marked in Experiment 11, in which the motor boat is at first slightly the faster. In Experiments 12 and 13 the initial lateral distance is respectively one and one third and ones and two thirds lengths, but the initial relative longitudinal positions are different in the two cases. In each case collision was produced. In Experiments 14 to 19—Fig. 4—the relative speeds were much greater than in the preceding cases. In Nos. 14, 15, 16 and 17 the speed of the Princess Louise was 3.75 knots, while that of the motor boat was respectively 3.9, 4.5, 5.1 and 5.4 knots. In each case the experiment was commenced with the smaller boat in approximately the same relative position, viz., about two lengths laterally distant, and about a length astern of the leader, and in each case the smaller boat was attracted. In No. 14 the speed of the vessel was insufficient to allow of its catching up the Princess Louise before being drawn in, and it passed under the stern of the latter. In Nos. 15 and 16 collision took place, while in No. 17 the motor boat, although considerably deflected from its course, ran past the Princess Louise without collision. In Experiments 18 and 19 the speed of the motor boat was 3.9 knots, and that of the Princess Louise was 5.9 knots. At the beginning of both experiments the smaller vessel was clear of the bows of the Princess Louise, and at a lateral distance of 1.5 lengths in No. 18 and 2.0 lengths in No. 19. Under these circumstances it was drawn into collision in No. 18, while in No. 19 the Princess Louise ran ahead before the deflection of the course of the motor boat was sufficient to produce collision, the latter boat running under the stern of the Princess Louise.

The authors would draw attention to the fact that collision, when produced by attraction from a comparatively large distance, is of a much more direct, and consequently dangerous nature than when the paths of the vessels are initially very close. In the former case the forces involved are operative for a sufficiently long time to produce a comparatively large angular deflection of the attacking vessel, the lateral component of whose own steaming speed becomes increasingly operative in increasing the velocity of approach. In the latter case the angular deflection is comparatively small, the velocity of approach is largely due to the bodily inward drift, and the vessels come together with a comparatively slight and innocuous broadside bump.

4. MAGNITUDE OF MOMENTS AND FORCES INVOLVED.

As previously indicated, the differences of the pressures obtaining at four corresponding equidistant points on the two sides of the smaller vessel were measured for different positions of this vessel, and the corresponding lateral forces and pressures have been calculated on the assumption that the pressure varied uniformly between consecutive gages. Owing probably to the clogging of one or more of the pressure openings by floating material, some of the pressure observations gave obviously inconsistent results during the course of a run, and only those experiments have been included in which these observations were consistent throughout. Experiments 20 to 24—Fig 4—are typical of these, and the relative positions of the vessels in these experiments are shown along with the magnitudes in foot-pound units of the corresponding moments (M) and lateral forces (F). Only during the latter portions of these runs were the various forces of sufficient magnitude to admit of reasonably accurate measurement by the method adopted, and only where those forces are greater than 10 pounds and the moments greater than 20 foot-pounds have these been given in the diagrams. Experiments 20 and 21 were carried out at a mean speed of 5 knots, and Experiments 22 to 24 at 3.61 knots.

The forces and moments acting on the smaller vessel depend on its lateral and longitudinal positions relative to the larger, and on the speeds of the two vessels. Under given speed conditions the sheering moment appears to attain its maximum value when the bows of the smaller are a little abaft of the beam of the larger vessel, the position of maximum sheer apparently receding slightly as the lateral distance increases, while when the bows are in line the force and moment are approximately zero. A further advance of the smaller boat is accompanied by an outward force and moment, with consequent repulsion of this vessel.

Both forces and moments diminish rapidly with an increase in later distance. For distances between one-half and three lengths the results show that the moment diminishes very approximately as the square of the lateral distance. Theoretical considerations indicate that forces and moments should increase with the square of the speed of the vessels. Actually in the experiments the rate of increase was slightly less than this. Since the turning moment exerted by the rudder is proportioned to the square of the speed, it follows, as was noted in the helm control experiments, that the vessel is somewhat more easily controlled against suction forces at high than at low speeds.

Calculations show that the controlling moments of the rudder in use during these experiments—area 1 foot square—are approximately as follows (measurements in foot-pounds):

Speed	Helm Angles.				
(knots).	5 deg.	10 deg.	15 deg.	20 deg.	25 deg.
5.0	100	180	280	340	400
3.6	52	93	145	175	210

From these figures it appears that the maximum moments measured in the experiments, viz., 240 foot-pounds at 5 knots and 160 foot-pounds at 3.6 knots, are such as would be controlled by helm angles of about 13 deg. and 16 deg., while when at a lateral distance equal to one length of the smaller boat, and in the position of maximum sheer, the helm angle for control would be approximately 8 deg. at 5 knots and 9 deg. at 3.6 knots. These values are very sensibly confirmed by the results of the helm control experiments.

5. HELM CONTROL EXPERIMENTS.

In the first helm control experiments a rudder having an area of 1 square foot was used on the motor boat. While considerably less than the rudder originally fitted to the boat, this has an area proportionately about 100 per cent. greater than is usual in high-speed sea-going vessels. It was anticipated that the effect of this would be to diminish the helm angle necessary for control by about the same percentage as compared with a large vessel under similar conditions, and with a view of testing this point a smaller rudder of 75 square inches area was afterwards fitted, and was used in a further series of trials. In each run the helms were manipulated so as to keep both vessels as near as possible on parallel courses, heading for the same distant point. Typical results of experiments with the large rudder are shown in Diagrams 25 to 30—Fig. 4—and with the smaller rudder in Diagrams 31 to 37. In these diagrams the speed of each vessel, the helm angle for each position of the motor boat, and the direction (port or starboard) of the helm, has been indicated.

An examination of the results shows that, as indicated by the gage observations, the maximum sheer is experienced when the bow of the smaller is a little abaft the beam of the larger vessel. The angle diminishes rapidly as the lateral distance between the vessels increases, and when these are moving at the same speeds (5 knots), and are at a lateral distance equal to one length of the smaller vessel, has a maximum value of approximately 6 degrees with the larger and 9 degrees with the smaller rudder. At a lateral distance of one half length this increased to about 10 degrees with the larger and 14 degrees with the smaller rudder.

It should be noted that in these trials all initial tendency to swerve was at once corrected by the helm, and was, in fact, anticipated as far as possible. Where such a sheer has once been initiated, and the vessels are traveling on convergent paths, a much greater helm angle is necessary to restore the attracted vessel to its original course. In experiments in which the helm was kept amidships until the two vessels were within

one half length of each other, the angle necessary to prevent collision with the larger rudder was approximately 17 degrees at 5 knots and 23 degrees at 3.6 knots. It will thus be seen that twice the amount of helm angle is necessary to prevent collision if the boat has once commenced to sheer in. The experiments indicate that, on the whole, the smaller vessel is under better control at the higher than at the lower speeds.

Diagrams Nos. 34 and 35—Fig. 4—are interesting as showing the comparatively large helm angle required to prevent an outward sheer when the smaller is ahead of the larger vessel, while Nos. 26, 30 and 37 show the (smaller) angle required to prevent outward sheer when the larger has drawn well ahead of the smaller vessel. The effect of a variation in the relative speeds of the vessels is well marked in Experiments 33 and 34. In the former the smaller at 5 knots is passing the larger vessel at 3.6 knots, with the result that when a little abaft the beam of the latter vessel and at a distance of one length 2 degrees of helm is sufficient for control. In No. 34 the larger vessel at 5 knots is passing the smaller at 3.6 knots, and when in the same relative position 10 degrees of helm is necessary for control. When both are moving at the same speed an angle of approximately 7 degrees is necessary in this position. It follows that any attempt of the larger vessel to draw ahead of the smaller by increasing the speed greatly increases the risk of collision. A somewhat surprising feature of the results is the comparatively small difference between the control exerted by the two rudders when under the influence of interaction. In the open the difference in their effect, as shown by the difference in the two turning circles, was very apparent, and the difference in the two sets of conditions is probably largely due to the fact that when in the vicinity of the larger vessel the greater turning moment of the larger rudder is partly masked by the more rapid inward drift consequent on the greater lateral pressure on its surface.

There is reason to anticipate that the tendency to sheer, as opposed to bodily drift, would be greater with an attracted vessel of greater relative dimensions than that used in the experiments. This vessel is in a field of force whose intensity varies from point to point, and which, consequently, gives rise to both a resultant force and a couple. The average magnitude of the force per unit area of the side of the vessel depends solely on the mean intensity of the field extending from stem to stern, and is therefore largely independent of the length of the vessel. It follows that the resultant force is increased in the same ratio as the area of the vessel, and with similar vessels in the ratio of the squares of corresponding linear dimensions. Since the weight of the vessel is increased in the ratio of the cubes of such dimensions, the resultant force per unit of mass of the vessel increases directly as the inverse of the linear dimensions, and, consequently, the smaller the attracted vessel the more rapid will be its inward drift. On the other hand, as the size of the vessel is increased the differences between the forces exerted at bow and stern become greater, and the resultant couple is increased in a greater proportion than the resultant force. As a consequence, the smaller the attracted boat the less relatively is its tendency to turn inwards about its own axis. With a very small boat, collision when it does occur is mainly due to the inward drift; the velocity of lateral approach is low, as it is only slightly affected by the steaming speed of this vessel, and the resultant impact is at a comparatively small angle. This conclusion receives some confirmation from the results of experiments on 20-foot models of equal size by Naval Constructor D. W. Taylor, of the United States Navy. In these experiments the models were attached to a carriage and were towed at the same speed. They were maintained in definite relative positions during a run, and the later forces required at bow and stern to prevent swerve were then measured by spring dynamometers. A comparison of these results with those of the author's shows that the proportional reduction in the resultant lateral force with the two smaller but equal vessels is much greater than the reduction in the sheering moment.

6. EFFECT OF AN INCREASED DRAUGHT OF THE ATTRACTED VESSEL.

With a view of determining the effect of an increase in the draught of the attracted vessel an additional series of experiments has been carried out during the past few weeks. For these a deeper keel was fitted to the motor boat, increasing its mean draught from 1.37 feet to 2.87 feet, without sensibly affecting its displacement.

Diagrams 38 to 42—Fig. 5—show the results of typical experiments on the vessel with the helm amidships, Nos. 38 to 40 being carried out in deep water and 41 and 42 in water having a depth of about 12 feet. A comparison of Nos. 38 and 39 with Nos. 7 and 3—Fig. 3—which are very similar as regards speed and lateral distance, appears to indicate that the effect of the increased draught is slight, and that collision is produced within about the same time in each case. This is, however, to be qualified by the fact that in runs 38 and 39 the vessel was exposed to a breeze on the port bow equivalent, as was shown afterwards, to a helm of about 3 degrees, so that, in effect, in these two experiments a constant helm of roughly this amount was tending to keep the vessels apart. In Experiment 40—compare No. 4, Fig. 3—the smaller vessel was under the lee of the larger, and in this case the attraction is notably greater than with the shallower keel. In Experiments 41 and 42, in which the depth of water was only about one half that in the other experiments, the general opinion of the observers, confirmed by the plotted results of the experiments, was that the attraction was somewhat greater than in the deeper water, although the difference was not very pronounced.

Diagrams 43 to 46—Fig. 5—show the results of helm control experiments, in which the same rudder, 1 square foot area, was used as in Experiments 25 to 30—Fig. 4. A comparison of these two sets of experiments shows that the helm required to prevent swerve is very appreciably greater with the deeper keel—about twice as great, in fact, as with the shallow keel under otherwise similar circumstances. At equal speeds (5 knots) at a lateral distance of half a length in the position of maximum sheer, a helm angle of about 17 degrees is necessary to prevent sheer as against 10 degrees with the shallow-keeled vessel, while where the helm is kept amidships until within this distance a helm of 35 degrees was sometimes insufficient to prevent collision.

GENERAL CONCLUSIONS.

In general the greater the difference between the speeds of the vessels the smaller is the risk of collision, since such a difference reduces the time during which the mutual forces are operative, such an effect being much more marked when the smaller vessel is the faster. If the larger vessel is the faster, particularly if her speed be accelerated while passing the smaller, the attractive forces are increased to an extent which partially, and in some cases entirely, counterbalances the effect of the reduction in the time during which the vessels are in dangerous proximity. It follows that any attempt of the larger vessel to draw ahead of the smaller by increasing her speed, while in close proximity, greatly increases the risk of collision.

With vessels of the relative size used in these experiments, moving at speeds within 10 per cent. of each other, collision may be produced from a lateral distance as great as 3½ lengths of the smaller vessel, except in so far as prevented by helm action. The greater the draught of the attracted vessel for a given displacement and length the greater the probability of ultimate collision. The smaller the attracted vessel within limits the smaller is the angle of impact under given conditions, while the greater the lateral distance from which collision is produced the more direct and dangerous is the resultant impact.

On the whole, the results of the trials show that under certain circumstances interaction is a very real danger to navigation, even in deep and open waters. With ordinary vessels of the relative sizes adopted for the experiments, if the possibility of interaction is realized from the very first, and if all initial swerve is prevented by an early application of the helm, there would appear to be little danger even at lateral distances so small as one half the length of the smaller vessel, but once such a swerve has been initiated a much greater helm angle is necessary to control the vessel, and, failing immediate control, collision occurs within comparatively few seconds.

The Meaning of a Change of Two Inches in the Barometer

By A. F. Miller

On January 3rd, 1913, occurred a very low barometer; the mercury column fell from 30.3 to 28.3, a fall of 2 inches.

Now 2 cubic inches of mercury weigh 1 lb., therefore, from every 2,000 square inches a weight of one ton was removed. Since $\sqrt{2000} = 44.78$, on every square measuring 44.78 inches on the side in the whole area of low pressure there was a reduction of a ton weight. This for the writer's small garden was equal to 120 tons.

The newspaper statistics of the storm seem to indicate that the low pressure existed simultaneously over an area of at least 400 miles square. From this I calculated the difference of pressure as 321,159,168,000 tons.

Allowing 30 freight cars, each loaded with 20 tons, as a fair-sized train for one locomotive, I find that 535,265,280 trains would be required to transport the above mentioned weight of material (which equals in weight 10 inches of basalt removed from each square inch of the area of low pressure).

Allowing 500 feet as the length of each train of 30 cars, the trains would extend to a distance of 50,688,000 miles.

The superficial area of the body of a man of average size is about 6,000 square inches, therefore, a weight of 3 tons would be removed from his body by a fall of 2 inches of barometric pressure.

But within some 30 hours of the time of lowest pressure the barometer rose again to the height it had occupied before the rapid decline; thus the whole work was practically done twice over, that is, the weight was taken off and put back again.

The low barometer and subsequent rise were accompanied by a rather strong gale, which many noticed because of the roaring or howling of the wind. But what a fracas would be occasioned by the loading of the number of trains already mentioned and the transportation of the material to a distance of 400 miles in 30 hours. The great forces of nature work very quietly.

It is hardly surprising that in regions subject to earthquakes and volcanic eruptions great declines in the barometric pressure have been found to act as predisposing causes of these catastrophes.—*Journal of the Astronomical Society of Canada.*

SCIENTIFIC AMERICAN SUPPLEMENT

Founded 1876

NEW YORK, SATURDAY, OCTOBER 25, 1913

Published weekly by
Munn & Company, Incorporated, Charles Allen Munn, President
Frederick Converse Beach, Secretary and Treasurer
all at 361 Broadway, New York

Entered at Post Office of New York, N. Y., as Second Class Matter

The Scientific American Publications

Scientific American Supplement (established 1876) per year $5.00
Scientific American (established 1845) . . . . " 3.00
American Homes and Gardens . . . . " 3.00

The combined subscription rates and rates to foreign countries including Canada, will be furnished upon application

Remit by postal or express money order, bank draft or check

Munn & Co., Inc., 361 Broadway, New York

The purpose of the Supplement is to publish the more important announcements of distinguished technologists, to digest significant articles that appear in European publications, and altogether to reflect the most advanced thought in science and industry throughout the world.

Table of Contents